

April 1992/\$3.00

Mobile Radio Technology

The journal of mobile communications technology

A dramatic photograph of a lightning storm. A tall, slender radio tower stands vertically on the right side of the frame. The sky is filled with dark, heavy clouds, and a bright, jagged lightning bolt strikes across the middle of the image. The overall color palette is dominated by deep blues and greys, with the white of the lightning providing a stark contrast.

Grounding practices, p. 10

Test equipment
Microwave waveguide
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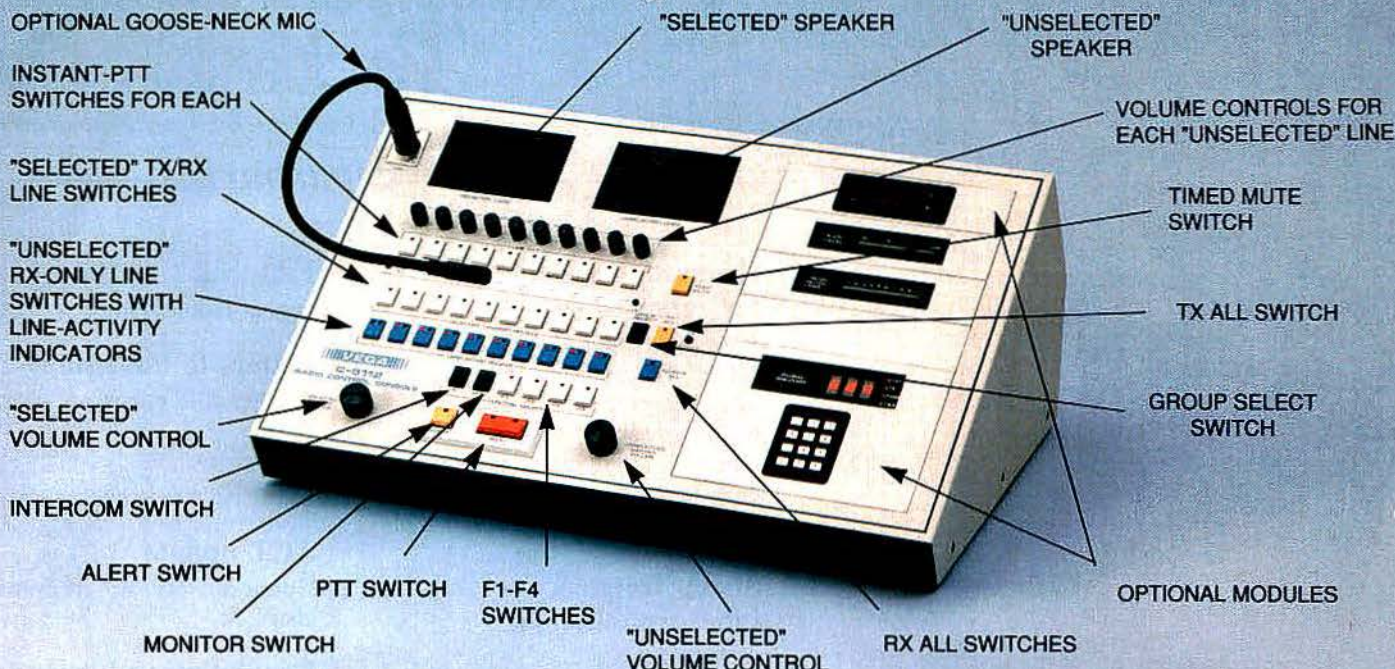
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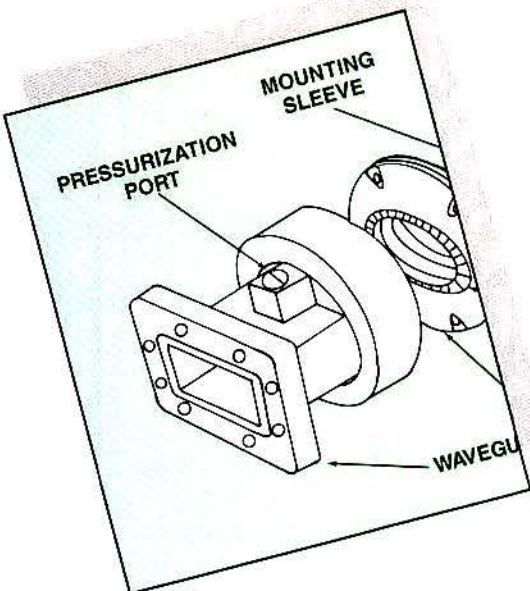
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On the cover: Lightning provides a backdrop to a repeater site at Snow Hill, OK. Composite photo courtesy of MCI Telecommunications. See article on page 10.

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Digital mobile radio



Aegis, Astro, MIRS... these are among the names that are ushering in digital technology that will redefine mobile radio communications for the '90s.

The binary language (ones and zeros) of digital computers opened the door decades ago. High-technology military and space operations brought digital techniques to communications.

Consumer demand for and acceptance of products and services based on digital technology have spurred research and development. Mass production of silicon chips bearing digital circuitry supports a vast quantity of products ranging from telephone switches to entertainment electronic equipment to information management systems.

Expanded features and improved quality appeal to consumers, as well as to business, industrial and government radio communications users.

Radio communications users want what consumers want: plenty of features (though they may not use them all), reasonable price and compatibility among products.

With digital mobile radio, communications users will get plenty of features and may get a reasonable price. Whether they will get compatibility among products remains to be seen.

In the meantime, manufacturers participate in standards committee meetings, such as the Europe's RES 6 and the United States' Project 25, and move ahead with product development.

Eriksen GE Mobile Communications has introduced *Aegis*, a line of digital mobile radio products. These prod-

ucts use a low-level digital modulation that occupies the current 25kHz bandwidth without multiplying channel capacity. The advantages are digital audio and increased signaling capacity for more features.

Motorola plans to make products with high-level digital modulation. Some of its products will split the existing channels to multiply channel capacity (frequency division multiple access or FDMA). The other products will split the time on existing channels to multiply channel capacity (time division multiple access or TDMA).

The diverse approaches mean the products will appeal to different users. The result may be that more users will be served by the multiple digital mobile radio technologies than would be served if only one type of product were offered, despite complaints that are sure to arise because one or more product lines will have been introduced before standards were set.

The mobile radio industry's use of digital technology trails behind that of other, larger industries. Nevertheless, radio communications users are likely to find the capabilities of digital mobile radio products as much to their liking as some of the digital consumer products they already use.

* * *

Digital standard

The public safety segment of the radio communications industry has reached an important milestone in its efforts to set digital radio standards. The task of setting standards has been undertaken by Project 25, an organization put together by the Associated Public-Safety Communications Officers and the National Association of State Telecommunications Directors.

Under terms of an agreement reached through negotiations among manufacturers, companies submitting technology to Project 25 have agreed to grant licenses on "fair and reasonable terms" for patents and copyrights they may hold that are necessary to manufacture equipment to meet the selected standards.

This agreement is an example of cooperation that may help to implement digital technology in the public safety

radio services. We congratulate the participants.

—Don Bishop

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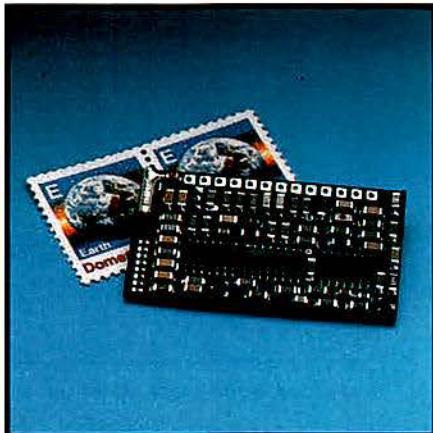
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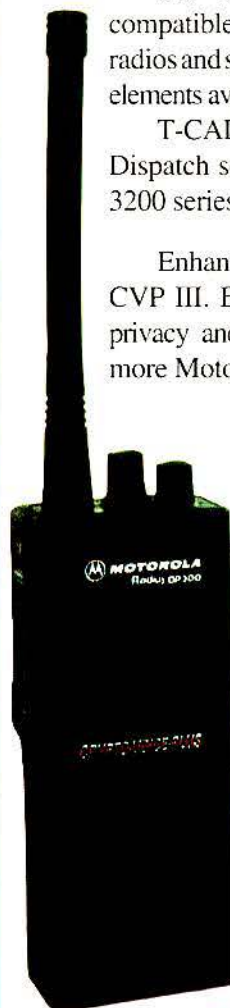
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Wind profile radar:

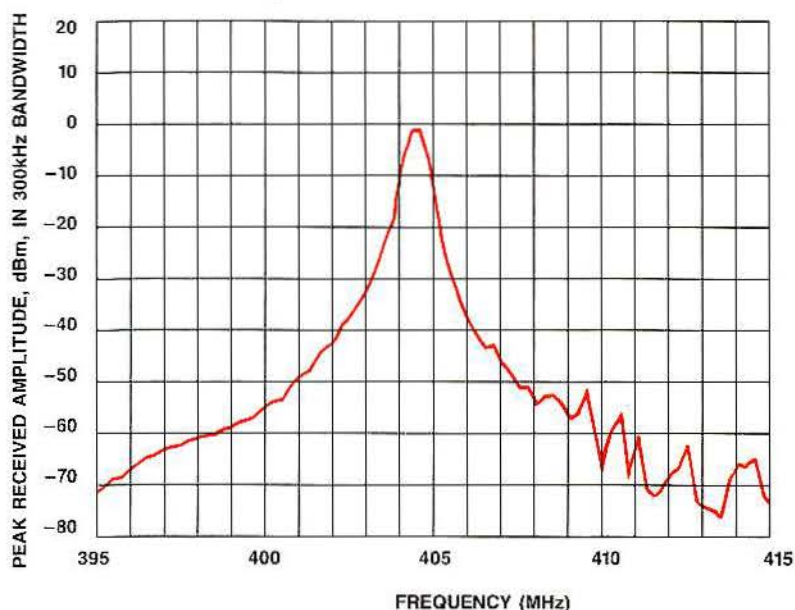
In early December 1991, it was brought to my attention that the National Oceanic and Atmospheric Administration (NOAA) will be required to relocate its existing wind profile radars from 404.370MHz to 449.000MHz.

There will be a significant amount of RF extending above and below the main carrier. The good news is that most of this energy is directed within 17° of straight up.

The bad news is that the main carrier's high mode will be approaching an effective radiated power (ERP) of 22MW, and the 30dB to 60dB of residual RF may not be enough to preclude interference or system degradation to those unfortunate to be within 5MHz of their operation.

This degradation to existing systems would be exposed further by the higher elevations and 3dB to 12dB gain antennas these services typically use.

An equally important consideration



The radiated, short-pulse spectrum of the wind profile radar at Platteville, CO.

Mobile Radio Technology

The journal of mobile communications technology

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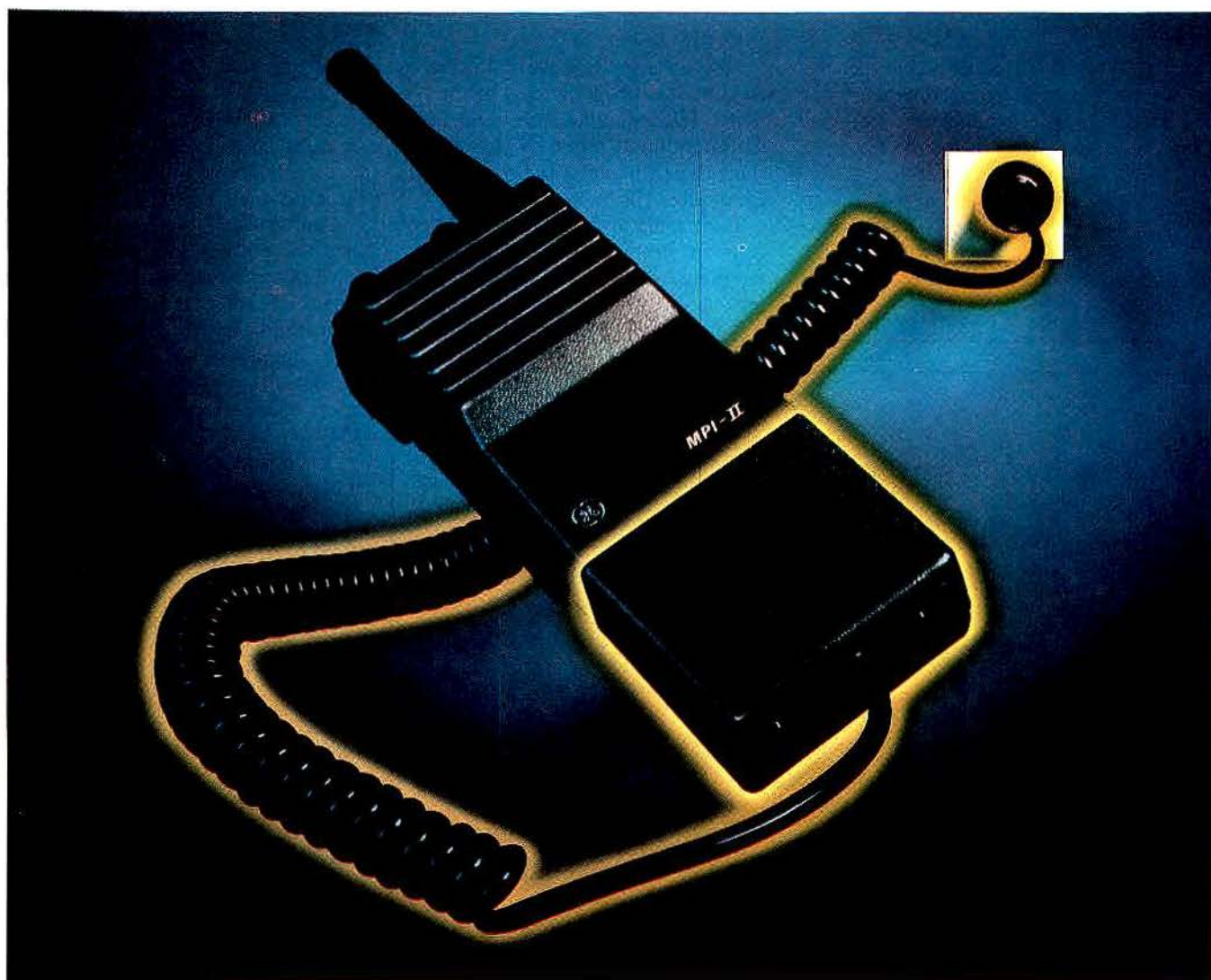
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Letters to the editor

would be the introduction of a generation of wideband intermod products that would be inserted into this saturated band segment and further be aggravated by the continuous carrier.

I have taped the audio component, and the resulting raspy audio from the composite signal is well within the audio acceptance of narrowband FM (NBFM) receivers.

This is not a move initiated by NOAA. It is being directed by the National Telecommunications and Information Administration (NTIA) and the Inter-departmental Radio Advisory Committee (IRAC).

Their main argument is based upon concerns of the rare instances of interference to the SARSAT/COSPAS satellite uplink systems on 406MHz to

408MHz.

The NOAA systems go to great lengths to inhibit operation during an overhead pass to negate potential interference to these birds. Nevertheless, there are some non-government entities and universities, domestic and foreign, that may not be as diligent.

NTIA's concern for safety-of-life issues is, of course, most valid. But then, so are the safety-of-life services provided by amateur radio operators sharing the 449MHz spectrum and the public safety radio services in the 453MHz-to-454MHz band.

Other radio services within the 10MHz envelope include Fire, Broadcast Auxiliary, Industrial, Land Transportation, Relay Press, Taxi, Petroleum Products, Local Government and Power, to name a few.

Surely there must be a better alternative to this move, news of which has been kept unusually quiet. It would seem that a minimal move downward in frequency could eliminate the infrequent satellite problem and cost the taxpayers a lot less than a banzai migration of 45MHz, altering the operational characteristics of thousands of existing amateur repeaters and perhaps compromising the performance of other commercial services.

Whit Brown

Frequency Coordination Chairman
Mid-America Coordination Council
Golden, CO

Fast Fact Card comment:

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J.P. Weisenhorn

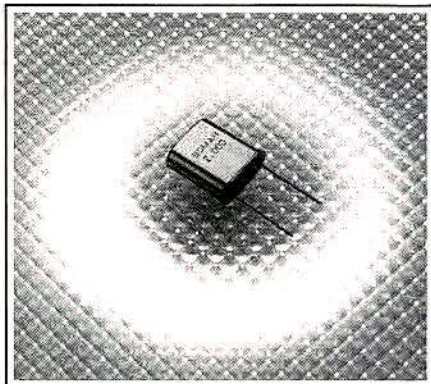
Weisenhorn Enterprises
Charlotte, NC

Correction

On page 33 of the January 1992 issue, the last line of the listing of existing services that APREL provides should read: "performance, comparative and QA testing."



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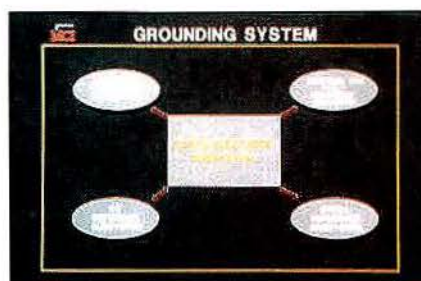
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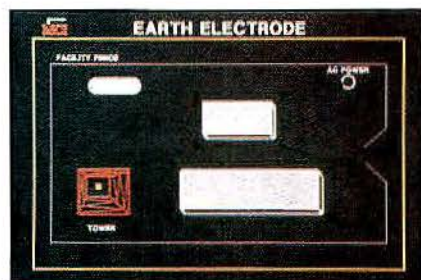
Grounding practices for repeater sites

MCI Telecommunications lightning protection techniques for microwave and fiber optic repeater sites offer helpful guidelines for other radio communications site operators.

By Henry Diaz and Harry Ouye



Five subsystems make up the grounding system.



The earth electrode subsystem (green) is a buried ring.



A portion of the earth electrode subsystem is buried in a trench that rings the facility shelters.

Diaz is manager of EMC and Protection Engineering Department, MCI Telecommunications, Richardson, TX. Ouye is the company's senior protection engineer.

Lightning-induced electric currents threaten many repeater facilities. Surge currents can injure people, damage equipment or both. Lightning happens during any and all weather conditions, not just thunderstorms.

Proper grounding for towers, buildings, fences and generators protects repeater facilities and workers from the risk of lightning damage.

Facility grounding

As with all types of facilities, the most basic approach to grounding is the establishment of an earth electrode subsystem. This subsystem is critical because lightning always looks to earth for a discharge path.

The earth electrode subsystem consists, for the most part, of a buried ring around the facility. The ring is constructed of buried ground rods interconnected by bare copper wire. The assembly is buried 2.5 feet to 3 feet deep, depending on soil conditions.

A similar ring circles the tower base.

Depending on the layout, another ring may circle the generator shelter.

All rings are interconnected to form an all-encompassing earth electrode subsystem.

All metal objects within the facility are connected to the ring, including shelters, fence, tower, fuel tank and ac neutral.

Tower grounding

The completed tower grounding assembly, designed almost exclusively for



Copper wire and ground rods are interconnected with exothermic welds. Here, a workman pours a catalyst into a mold.



The welding material is ignited, and metal flows from the wire and rod to form a connection free of mechanical and dissimilar metal contact.



Imaginary spheres placed tangential to the tower define a protected volume bounded by the tower, earth and the lower surface of the spheres. This volume sometimes is called the cone of protection.

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Keeping data on the move

lightning surge protection, is called the lightning protection subsystem. It ties into the earth electrode subsystem.

Typically, a tower is provided with a lightning rod that extends at least 2 feet above and close to the tallest object on the tower. This object may be a beacon or an antenna. When both are placed on top, two rods are mounted, one to serve each object. The rods are intercon-

nected at the top and connected to the tower frame.

Downconductors are provided to channel the surge currents to the earth electrode subsystem below. The downconductors are bare copper cables that run along the tower leg(s) outer face.

This configuration helps to intercept strikes occurring at intermediate levels. Because the tower, rods and downcon-



A technician clamps a grounding strap to exposed waveguide. Weatherproofing later is applied.

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ductors are interconnected, numerous parallel paths to ground are present, providing lower overall impedance to dissipate lightning currents. Theoretically, no one path contends with the full brunt of the current flow.

Items mounted on the tower receive special grounding treatments. Waveguide, antennas and electrical conduits are treated to dissipate the current surge without damage.

Waveguides are grounded at two or three points along their runs. Specifically, the waveguide for the uppermost antenna is grounded at a point near the antenna. The waveguides are grounded at the bottom of the runs just before making the vertical-to-horizontal transition. The waveguides are grounded once



Guy wires are interlaced with ground leads attached with clamps of a special, dissimilar metal type and connected with the guy anchor's earth electrode subsystem.

Two ways ROHN's 20 year tower warranty can make money for you

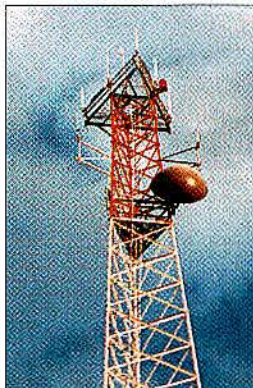
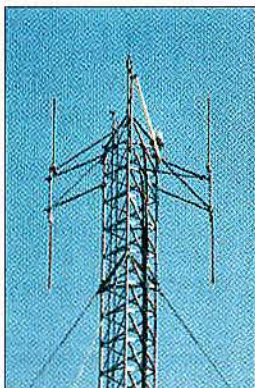


Insurance

Your insurance company may give you a reduced premium. Insurers love the ROHN warranty because it reduces their liability. For the first five years your tower is guaranteed against failure due to ice or wind in excess of design, and it is guaranteed for 20 years against failure due to corrosion.

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*"43 years of service to the
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again at the entry port leading into the facility.

These multiple grounding connections ensure that surge currents are shunted while still outside of the facility. In lightning-intensive areas, the additional precaution of grounding the waveguide flex-to-rigid transition inside the facility is taken.

Antennas are grounded inherently

through incidental contact with the tower as part of the mounting process. Feed horns typically are grounded to the tower frame.

Ac conduit delivering power to the tower beacon is grounded at the vertical-to-horizontal transition.

Additional tower grounding is provided at the waveguide ice shield and support structure. These assemblies are

bonded and grounded to the tower ring to discourage icing. Climbing ladders that extend close to the ground are grounded to the ring. The facility fence is bonded and grounded to the tower ring.

Electrically speaking, these measures are intended to present a continuous, low-impedance discharge path to an impending strike.

Shelter grounding (external)

Equipment shelters are grounded to the earth electrode subsystem at each corner of the skids.

These connections, as with most ex-

RANGER

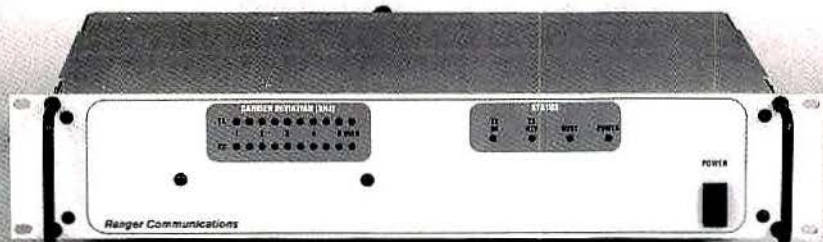
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Ranger's repeater line is housed in a standard 19" compact rack enclosure and includes a built-in, auto select 110/220 VAC power supply. There is plenty of room left over to mount the optional duplexer, CTCSS and/or the NRZ digital paging board. Ranger's use of a standard 15 pin multi-function interface connector (MFI), ideally located on the rear of the unit, makes for very easy installation of external accessories and options.

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Lightning damage

Direct strikes, ac power surges, inductive coupling and ground potential rise are ways in which lightning inflicts damage.

A typical lightning strike can produce thousands of volts and a proportional current flow. Currents range from hundreds to thousands of amperes during the course of the discharge.

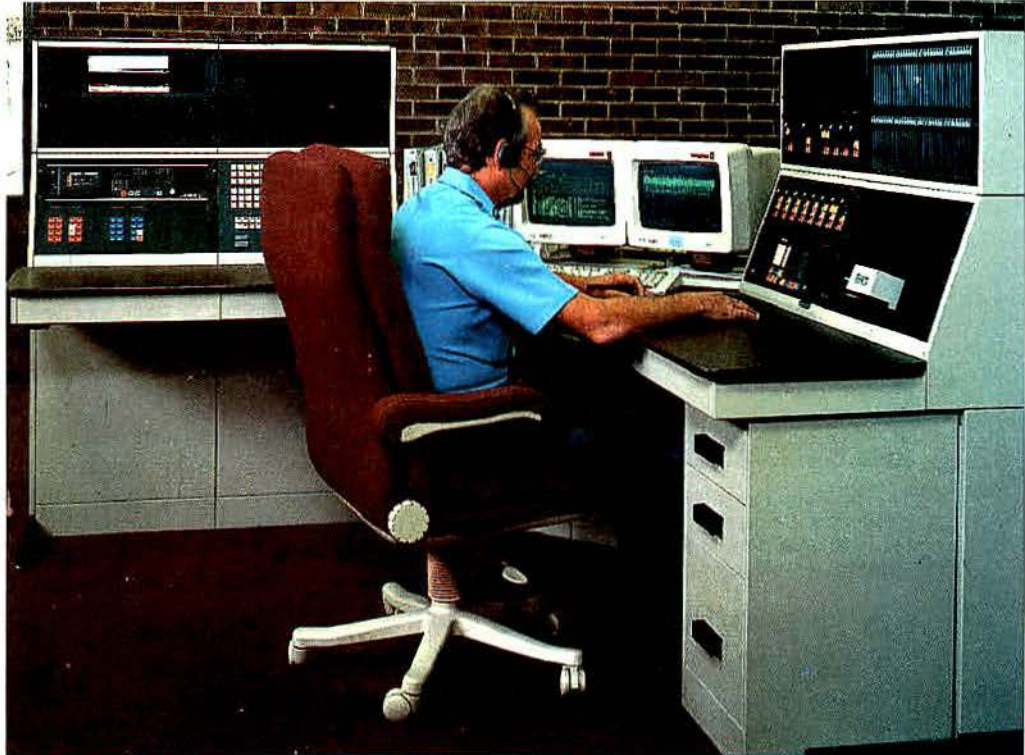
Lightning may be drawn to any object in the vicinity, and may not necessarily strike the tallest. Sometimes lightning strikes towers below their tops or objects side-mounted to towers.

ternal bonds, are exothermic welds. The interior grounding system eventually terminates at the shelter skids, thus completing the bond between the internal and external metals.

All cables and wire entering and exiting the shelter are surge-protected. The ac service entrance is equipped with a fast-clamping surge arrestor that provides an external alarm in the event any phase is unprotected through arrestor failure.

Fiber optic cable sheaths and metallic strength members are severed and grounded at the facility entrance. Conduits, pipes and fuel lines are bonded and grounded properly to the external

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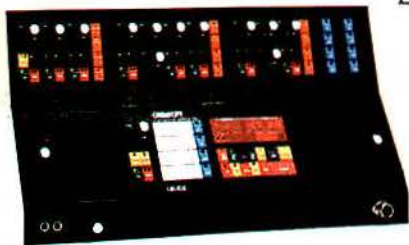
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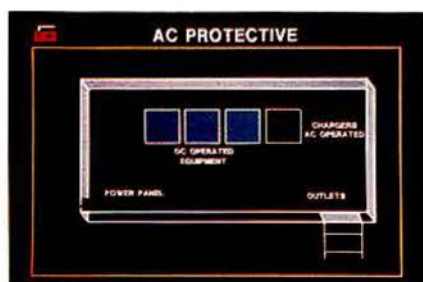
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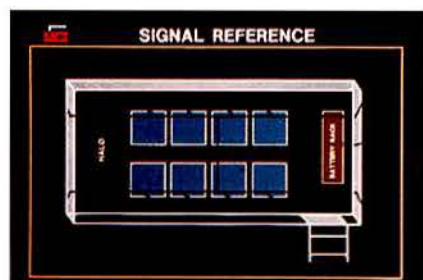
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The ac protective subsystem (green) is a dedicated wire safety network that protects people and equipment from ac-generated fault currents.



The signal reference subsystem (green) grounds dc-operated equipment racks and cabinets, and handles higher frequencies.

grounding ring.

All precautions are taken to ensure that metal objects within the facility rise and fall at the same electrical potential during an electrical surge while surge currents pass harmlessly through preselected channels.

Shelter grounding (internal)

Inside the shelters, similar measures are taken to bond and ground all metal objects, racks and frames using selective internal grounding systems that eventually terminate to the earth electrode subsystem.

The ac power distribution system is provided with a dedicated green wire safety network intended to protect people and equipment from ac-generated fault currents. This system is called the equipment protective subsystem and is required at all MCI facilities, regardless of type.

The dc-operated communications equipment similarly is provided with a safety-signal grounding system specifically designed to handle the higher fre-

quencies inherent to this type of facility. All racks and cabinets of dc-operated equipment are grounded selectively to this dedicated system. Call the signal reference subsystem. It has multiple connections to the earth electrode subsystem.

The battery plant for the facility is referenced to the earth electrode subsystem by dedicated means. The dc power distribution system is provided with an isolated dc return path to ensure that all dc return currents are channeled back to the battery through dedicated means.

This provision avoids dividing dc return currents among other grounding conductors and provides interference-free dc power, as well as limiting externally produced surge currents within the dc distribution system.

Acknowledgement

This information first appeared in the ENTELEC '89 Technical Papers volume.



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PC8910N	896-940	11	125	200
PC9010N	928-960	12	125	200
PC904N	895-980	6	125	200

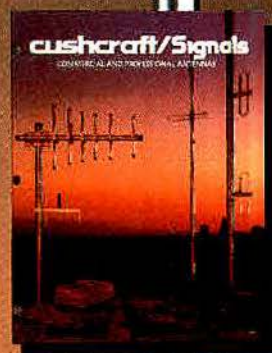
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Omni Selector Guide

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S8960B	896-960	Unity	125	200
S8064B	806-866	4	125	200
S8964B	896-960	4	125	200

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Sweep frequency to tune, troubleshoot antennas

Reflected signal measurements made over a wide range of frequencies provide a better picture of antenna performance than pulsed TDR or VSWR readings. Demanding users require on- and off-frequency readings.

By Wayne R. Openlander

Radio installers and service technicians encounter many situations that cannot be analyzed with a transmitter and wattmeter alone. Knowledgeable antenna users are aware of this and require that off-frequency as well as on-

Openlander is chief technology officer at Direct Conversion Technique, Des Plaines, IL. The company manufactures the portable scalar network analyzer mentioned in the article.

frequency reflection measurements be made—both before and after an antenna is installed.

Such on- and off-frequency measurements sometimes are called frequency domain reflectometry (FDR) to differentiate them from time domain reflectometry (TDR) measurements.

Frequency domain measurements are used because they can analyze antenna and feedline performance at all operating frequencies, whereas TDR is much more limited in its capabilities.

Figure 1 below shows just how much information a single FDR measurement

can yield. From this one sweep, the antenna's center frequency and bandwidth, and the transmission line's length and power loss may be determined.

Background

TDR measurements were developed for TV cable quality control and popularized for community antenna television (CATV) systems troubleshooting. But TV signals, unlike FM radio signals, contain amplitude modulated pulses for picture and synchronization information.

Because TDR simulates a TV signal's

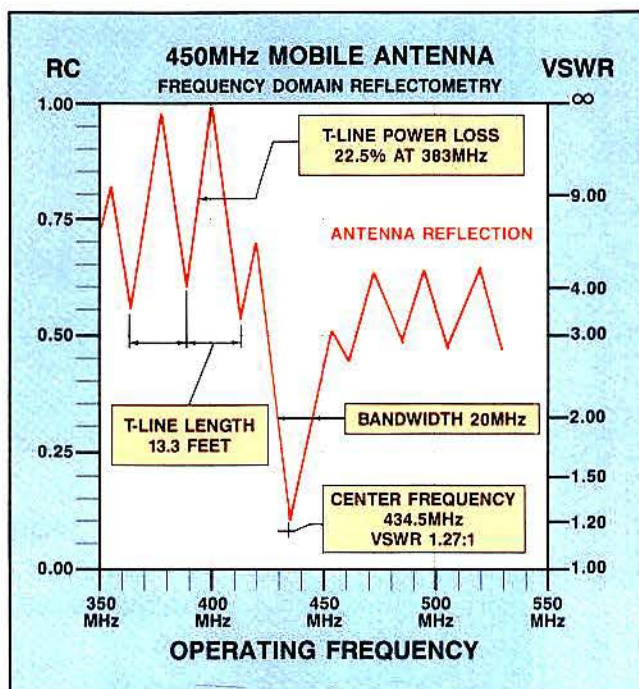


Figure 1. A single FDR measurement can yield much information. From this one sweep, a 450MHz mobile antenna's center frequency and bandwidth, and a transmission line's length and power loss may be determined.

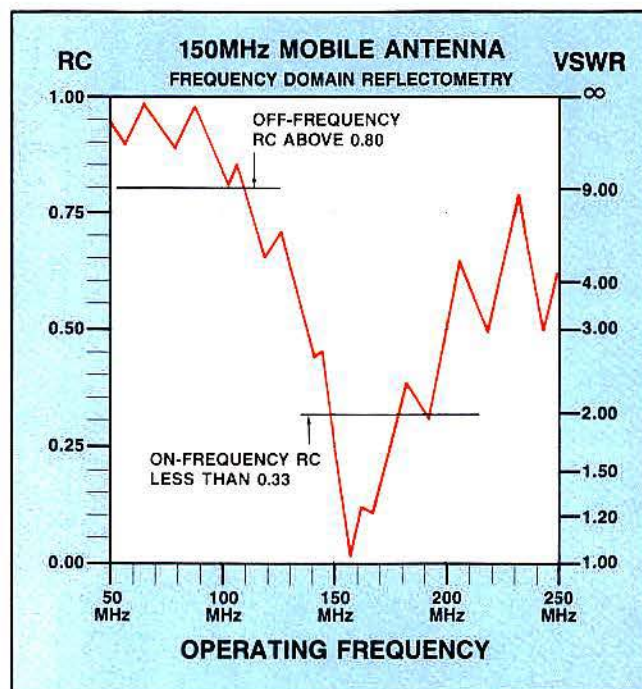
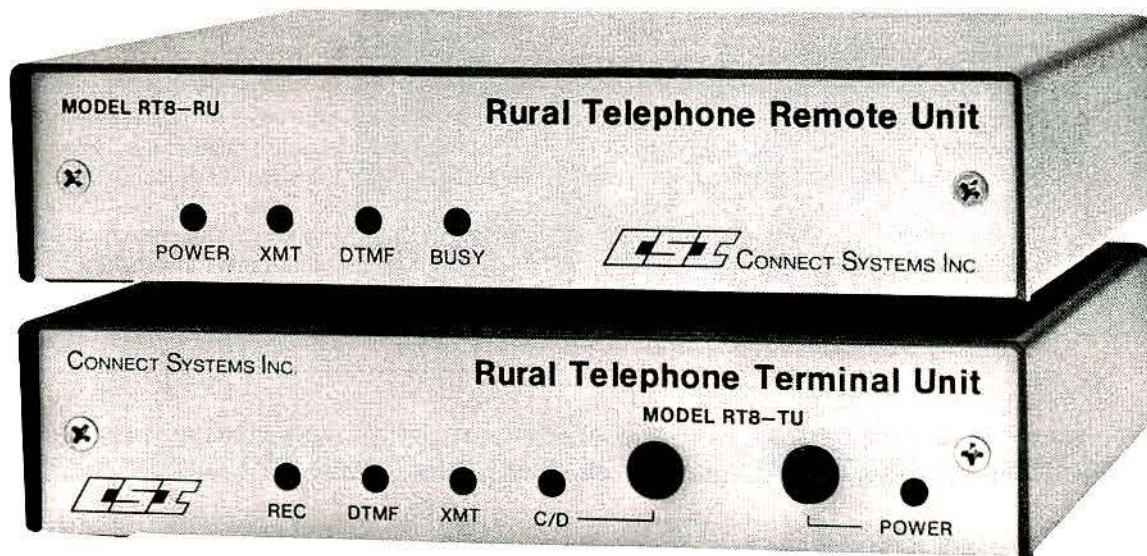


Figure 2. Chart of a satisfactory antenna. The off-frequency reflection coefficient is greater than 0.80. The VSWR at the operating frequency is better than 1.20:1.

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Comparison of commonly available FDR measurement instruments

SWR analyzer

Typically \$90-\$100

Intended primarily for radio amateurs and shortwave listeners, the SWR analyzer is available in two versions, one to cover 1MHz to 30MHz, the other to cover 140MHz to 170MHz. The analyzer's frequency display is a printed dial. The 1MHz-to-30MHz version uses a bandswitch to cover the frequency range.

Antenna match indicator

Typically \$650-\$950

Versions of the antenna match indicator are available in the frequency band from 1MHz to 500MHz, the UHF highband and the cellular and specialized mobile radio (SMR) bands. These instruments use either a printed dial or a voltmeter to display frequency. The 1MHz-to-500MHz version has a digital voltmeter and bandswitching. The other versions cover single bands. The frequency accuracy is specified as $\pm 2\%$, and SWR accuracy is estimated as -15dB equivalent directivity.

Continued on page 22

requirements. TDR pulses can, by measuring the echo's time delay, find the location of the ghost-causing flaws in a cable TV system.

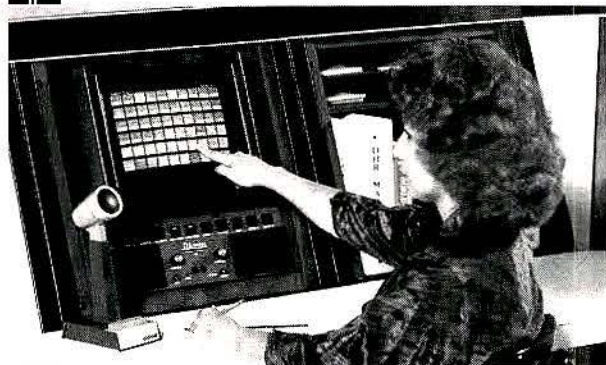
FM systems respond much differently to ghosts and echoes than video systems do. For most purposes, minor flaws in an FM radio system cause no appreciable losses. Instead, they slightly increase the transmission line ripple and shift the connected elements' apparent resonances.

The result is that, although pulsed TDR measurements may give an interesting picture of the connectors, transmission line and antenna, they give little information about the actual performance.

Frequency domain measurements, on the other hand, accurately simulate the cable's actual use. Even though the desired TDR echo may be extracted from the FDR measurement, frequency domain measurements give the user additional information about the system's frequency-selective performance.

Therefore, for FM systems, FDR

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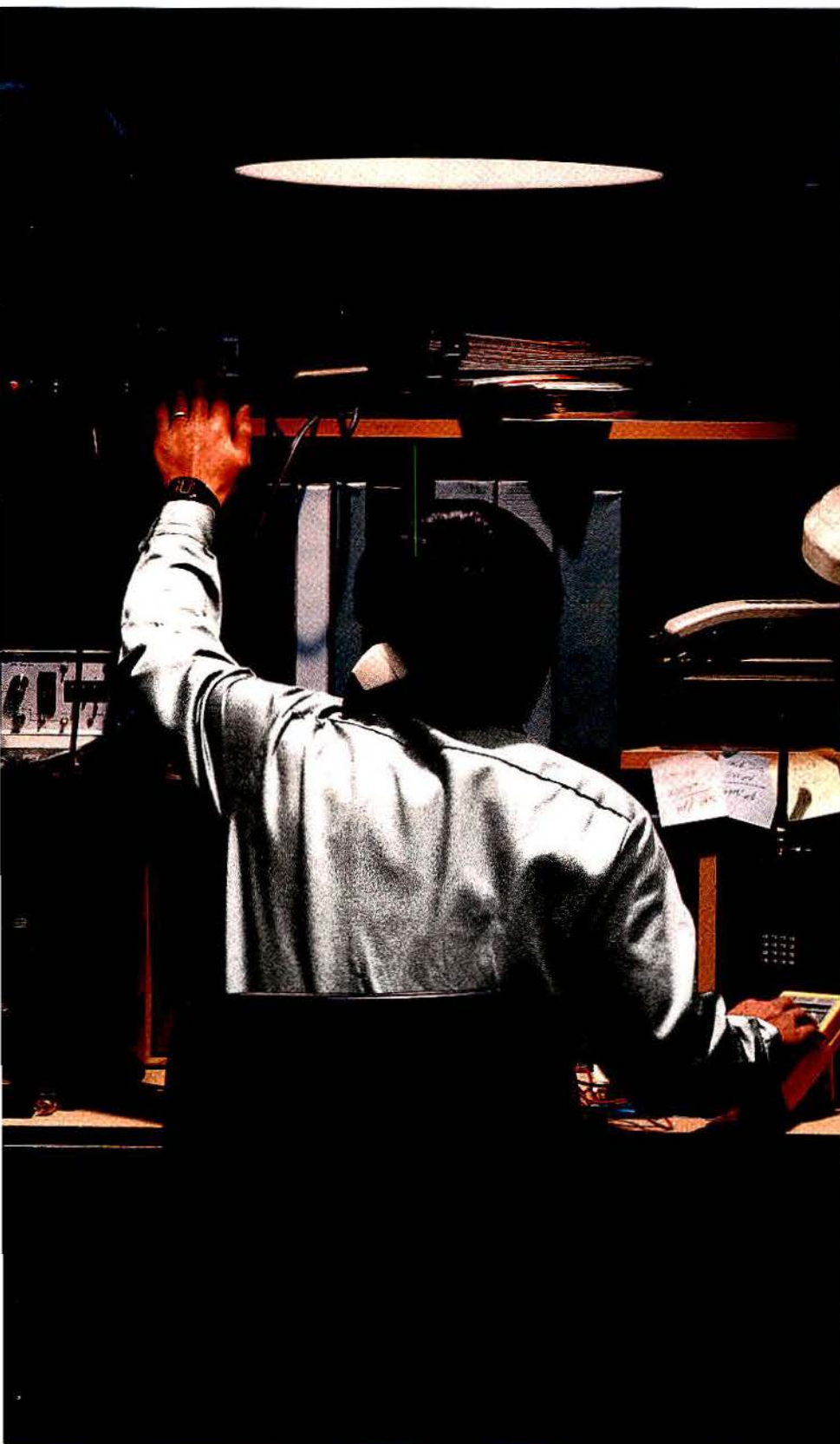
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Continued from page 20

Scalar network analyzer

Typically \$1,800-\$2,000

Versions of the scalar network analyzer are available for 1.5MHz-to-60MHz, 10MHz-to-525MHz and 700MHz-to-1,200MHz ranges. All versions have continuous tuning with no bandswitching. They have temperature-compensated oscillators, temperature- and linear-compensated RF detectors and a frequency counter display. The frequency accuracy is better than 100ppm. The user can calibrate the SWR accuracy to better than -20dB equivalent directivity.

Spectrum-network analyzer

Typically \$12,000-\$24,000

A spectrum analyzer is combined with a tracking signal generator and an external reflection bridge to form a spectrum-network analyzer. The instruments cover from 100kHz to 1.2GHz or 2.4GHz. The signal generator is a swept-frequency synthesizer. Measurements are displayed on a cathode-ray tube (CRT) or output to a printer or plotter. Frequency accuracy of 10ppm is typical. SWR is displayed in decibel return loss with 30dB to 40dB equivalent directivity.

Continued on page 24

measurements are far more useful and desirable than TDR measurements.

FDR measurements

First determine whether the antenna installation meets industry standards.

Most installers accept a maximum reflection loss of about 10% (a 10dB return loss or 2:1 VSWR), yet they also accept transmission line losses of as much as 20% (a 1dB insertion loss). This willingness to accept higher transmission line than reflection losses probably stems from misunderstandings about the availability of FDR measurements.

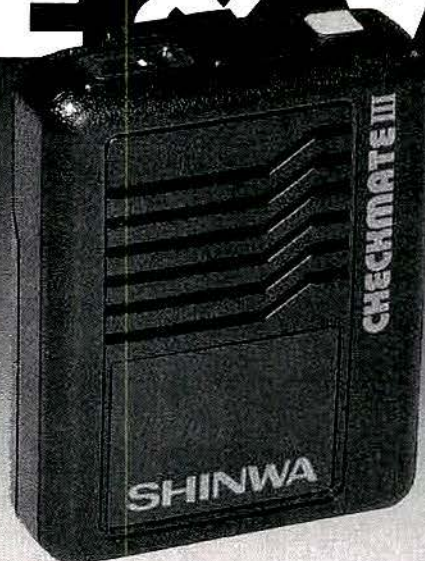
Figure 2 on page 18 shows, in schematic form, the swept-frequency loss of an antenna that exceeds the industry standards (10% reflection loss).

Notice that the degree of reflection is expressed as a reflection coefficient (RC) as well as VSWR. VSWR measurement is useful only with lossless transmission lines connected to nearly ideal antennas. Rather than VSWR, the antenna expert is more likely to use ei-

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Continued from page 22

Vector-network analyzer

Typically \$23,000 and more

The most advanced of the FDR instruments, the vector-network analyzer can include software for FDR-to-TDR conversion. It displays the time domain equivalent of the FDR measurement. It displays decibel return loss or Smith chart polar graphs on its CRT or an external plotter with 10ppm frequency accuracy and -60dB or better equivalent directivity.

ther return loss (the power ratio expressed in decibels) or reflection coefficient (the voltage ratio) to express the degree of reflection present on the transmission line.

Reflection coefficient is the easiest value to express and to use in making calculations. The equivalent VSWR is included in parentheses. Table 1 on page 26 shows the conversion from RC to VSWR and the effect on transmitted power.

Figure 2 shows that, for an antenna to meet or exceed the threshold of acceptability (10% power lost from reflection; 20% from transmission), the off-frequency RC must average 0.8 (9:1 VSWR) or higher, and the on-frequency RC must be 0.33 (2:1 VSWR) or lower.

Figure 3 on page 26 shows a situation in which the antenna or transmission line is defective. A transmission line with excessive insertion loss, whether caused by water in the line or by deterioration of the shield or dielectric, shows off-frequency RC values of less than 0.8.

Remember to take an average of the off-frequency RC to eliminate variations caused by the transmission line itself. In Figure 3, a typical UHF antenna is connected to the transmitter with a transmission line loss of 3dB or more. Notice that the off-frequency RC never exceeds 0.5 (3:1 VSWR) while the on-frequency RC is an excellent 0.05 (1.1:1 VSWR).

Figure 4 on page 28 shows measurements made with a 450MHz collinear magnetic-mount antenna. As part of a quality-control program, the antenna was measured as it came from the box: The transmitter-end connector was installed improperly at the factory.

The frequency domain plot for this antenna shows the unusual degree of off-frequency cable ripple. This excessive ripple indicates a transmission line fault or break. In this example, the system shows a good VSWR at 456MHz and, despite the bad connector, it would pass most antenna-testing procedures. The antenna's actual resonance, before cutting, is just above 430MHz.

Figure 5 on page 28 shows measurements made on a system with a transmission line break. In this example, the RC always is higher than the 0.33 value

Continued on page 32

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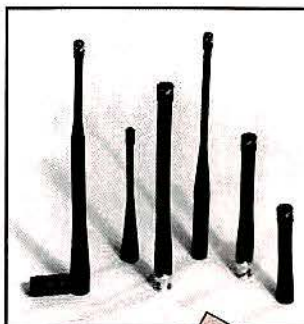
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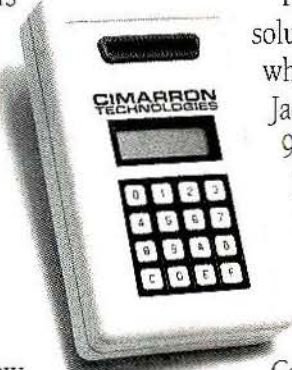
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Table 1—Effect of VSWR on transmitted power.

RC	VSWR	RETURN LOSS (DB)	TRANS. LOSS (DB)	POWER REFL. %	POWER TRANS. %
.00	1.00	∞	.000	0.0	100.0
.01	1.02	40.00	.000	0.0	100.0
.02	1.04	34.00	.002	0.0	100.0
.03	1.07	30.50	.005	0.1	99.9
.04	1.09	27.90	.008	0.2	99.9
.05	1.11	26.00	.012	0.3	99.7
.06	1.13	24.40	.016	0.4	99.6
.07	1.15	23.10	.021	0.5	99.5
.08	1.17	21.90	.027	0.6	99.4
.09	1.20	20.90	.036	0.8	99.2
.10	1.22	20.00	.044	1.0	99.0
.13	1.30	17.70	.074	1.7	98.3
.15	1.35	16.50	.101	2.3	97.7
.17	1.41	15.40	.128	2.9	97.1
.20	1.50	14.00	.177	4.0	96.0
.25	1.67	12.00	.283	6.3	93.7
.30	1.86	10.50	.410	9.0	91.0
.33	2.00	9.50	.501	10.9	89.1
.35	2.08	9.10	.570	12.3	87.7
.40	2.33	8.00	.757	16.0	84.0
.45	2.64	6.90	.985	20.3	79.7
.50	3.00	6.00	1.250	25.0	75.0
.60	4.00	4.40	1.940	36.0	64.0
.70	5.67	3.10	2.920	49.0	51.0
.80	9.00	1.90	4.440	64.0	36.0
.90	19.00	0.91	7.210	81.0	19.0
1.00	∞	0.00	∞	100.0	0.0

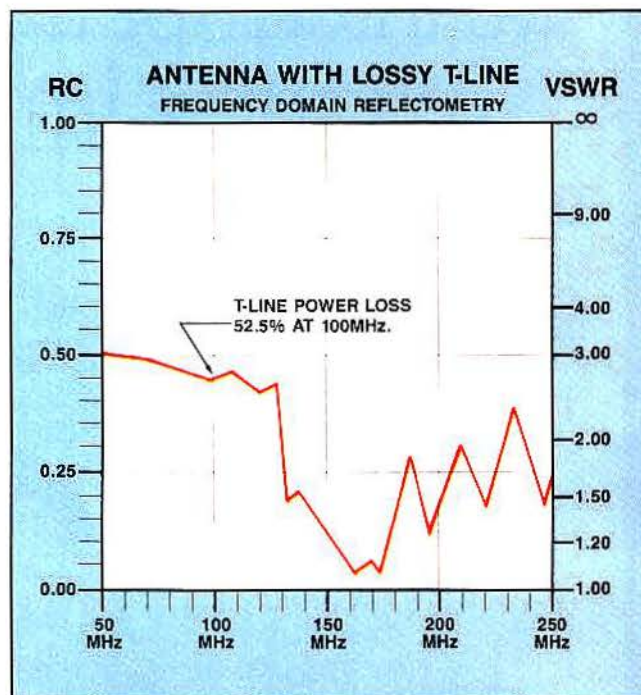


Figure 3. Chart of a 150MHz mobile antenna with a lossy transmission line. The antenna provides an excellent VSWR over an exceptional bandwidth, but the off-frequency RC never measures higher than 0.50%.

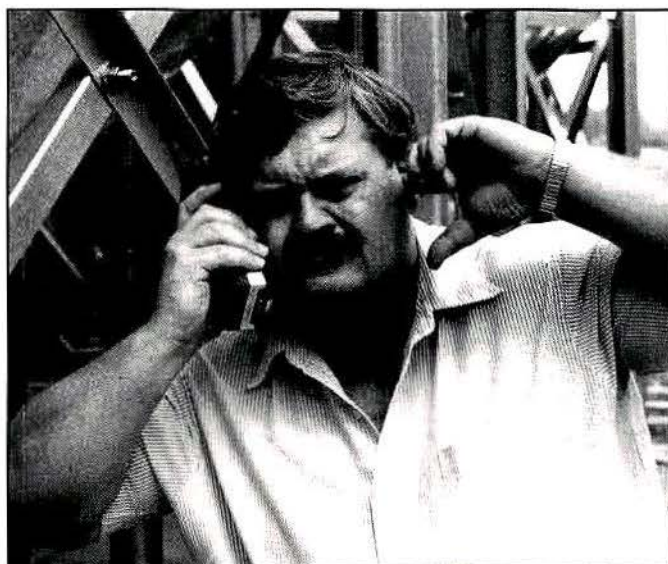
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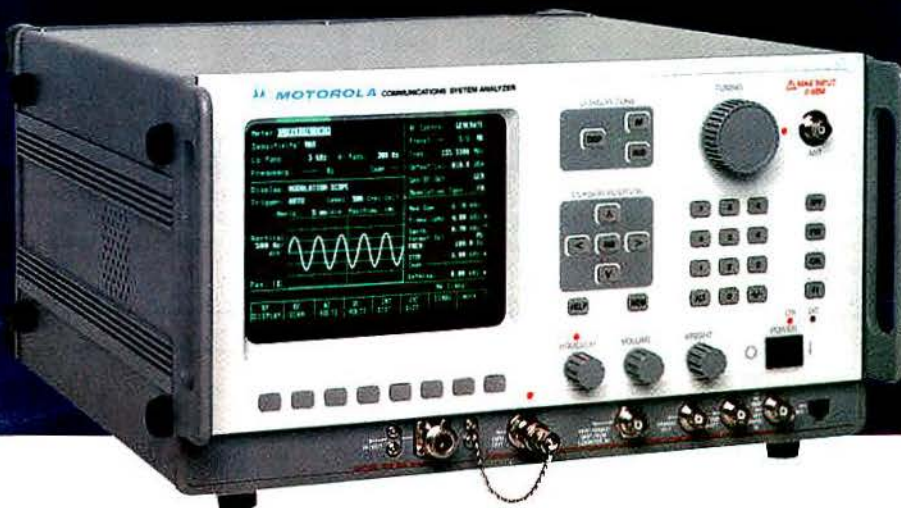
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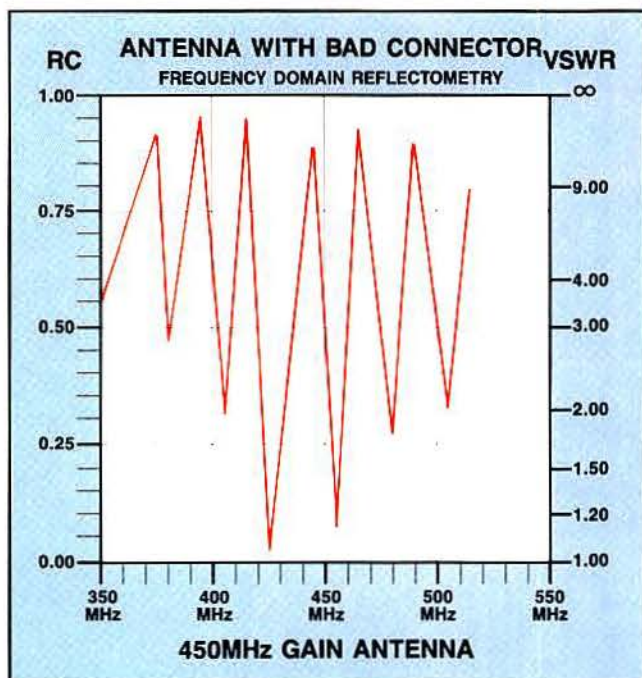


Figure 4. Chart of a 450MHz, magnetic-mount gain antenna. The manufacturer attached the transmitter connector incorrectly. The antenna provides a remarkably suitable VSWR at 456MHz, and it would pass most inspections.

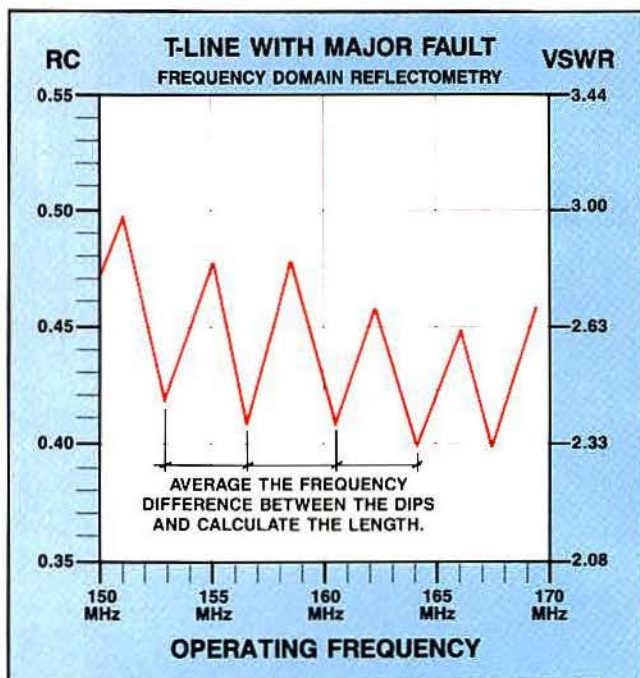


Figure 5. This is the chart of a transmission line with a major fault: It was cut about 100 feet from the transmitter. The halfwave frequency is 3.84MHz. Notice the expanded RC and frequency scales.

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Continuous:	100 watts	200 watts	500 watts
Input Voltage:	10 to 15 VDC	10 15 VDC	10 to 15 VDC
Output voltage:	115 VAC RMS \pm 5%	115 VAC RMS \pm 5%	115 VAC RMS \pm 5%
Output frequency:	60 Hz \pm 2%	60 Hz \pm 0.01%	60 Hz \pm 0.01%
Output waveform:	modified sinewave, phase corrected	modified sinewave, phase corrected	modified sinewave, phase corrected
Efficiency:	90%	90%	90%
Low battery alarm:	10.7 V	10.7 V	10.7 V
Low battery shutdown:	10 V	10 V	10 V
Dimensions (H x W x L):	1.2" x 3.5" x 4.5"	1.5" x 4.5" x 6"	3" x 9" x 10"
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Short Circuit:	Electronic shutdown	Electronic shutdown	Electronic shutdown
Reverse polarity:	Fuse	Fuse	Fuse

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Fault location, transmission line ripple

A transmission line terminated at the far end in an open circuit, a short circuit or a dummy load returns to the near end a reflected signal with a varying amplitude depending on the input signal frequency.

As the frequency changes, the RC from the transmission line shows a repeating series of peaks and dips. This ripple is caused by the constructive and destructive phase interference from the multitude of small reflections in the measurement system.

The dips occur at frequencies corresponding to $n/2$ wavelengths of the distance from the generator to the load or mismatch at the far end.

When an antenna or other useful load is attached to the transmission line, this ripple is superimposed on the load's reflection characteristics.

The lowest dip frequency, the frequency at which the cable is $1/2$ -

wavelength long, may be calculated by averaging the difference in frequency between several successive dips. Averaging is required because the interior reflections within the transmission line do not give dips at exact frequency multiples.

The transmission line length from the generator to the fault may be found by dividing the average difference frequency between the dips into the transmission line's velocity factor. Typical velocity factors (half the signal velocity in the cable) are:

- ▶ 325 feet/microsecond for solid dielectric cables (0.66 velocity factor).
- ▶ 394 feet/microsecond for foam dielectric cables (0.80 velocity factor).
- ▶ 492 feet/microsecond for air (1.0 velocity factor).

For the open coaxial cable example presented in Figure 5, the calculations are: Dip 1, 152.88MHz; Dip 2,

156.56MHz; Dip 3, 160.44MHz; Dip 4, 164.40MHz. The average dip frequency difference is 3.84MHz. The cable length (#8214 foam dielectric) is 102.6 feet.

Insertion loss

The insertion loss calculation assumes that the antenna is effectively an open circuit when it is measured away from its operating frequency. Because an open circuit reflects all the signal, it has an RC of 1.0 (VSWR of $\infty:1$). The measuring signal nevertheless is reduced by traveling up the transmission line to the end and then back to the measuring point. The reduction of RC from 1.0 therefore measures the cable attenuation.

An RC measurement of 0.8 means that only 64% of the signal introduced into the cable is being reflected to the measurement point. The 0.8 figure is the reflected voltage, which, when squared, yields 0.64 for the reflected power.

The RC measurement is a round-trip path. To derive the one-way loss, subtract RC from 1.0. Table 2 is provided for this purpose.

Although it is not entirely accurate to assume an open circuit, if some judgment is used in selecting the test frequencies and if the peak and dip measurements are averaged, this method yields useful approximations.

For the example in Figure 3, the calculations are as follows: Frequency 1, 95MHz, RC, 0.40; Frequency 2, 105MHz, RC, 0.45. The average frequency is 100MHz, and the average loss is 52.5%.

Table 2—Estimate T-line losses using off-frequency reflection measurements.

RC	T-LINE LOSS (DB)	POWER LOSS (%)	RC	T-LINE LOSS (DB)	POWER LOSS (%)
1.00	0.00	0.0	.50	3.01	50.0
.95	0.22	5.0	.45	3.47	55.0
.90	0.46	10.0	.40	3.98	60.0
.85	0.70	15.0	.35	4.56	65.0
.80	0.97	20.0	.30	5.23	70.0
.75	1.25	25.0	.25	6.02	75.0
.70	1.55	30.0	.20	7.00	80.0
.65	1.87	35.0	.15	8.24	85.0
.60	2.22	40.0	.10	10.00	90.0
.55	2.60	45.0	.05	13.00	95.0

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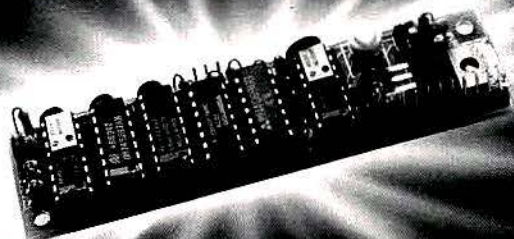
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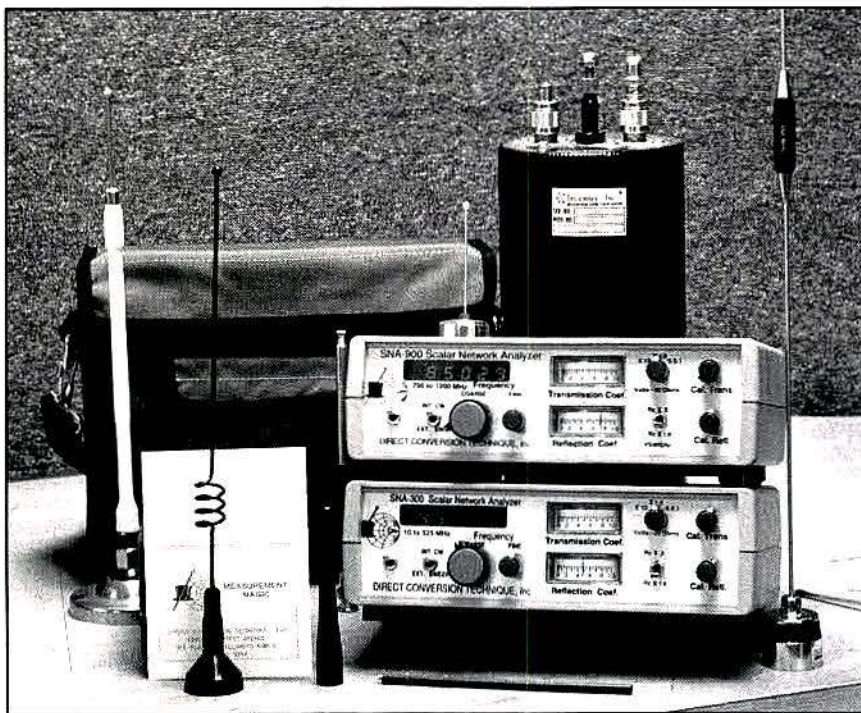


Photo 1. A low-cost alternative of a spectrum-network analyzer is the portable scalar network analyzer. It combines an ultra-stable signal generator, frequency counter and reflection bridge in a battery-powered package.

Continued from page 24

set as a standard for this article. By calculating the halfwave frequency from the input to the break, the break's location can be pinpointed. (See "Fault Location and Transmission Line Ripple" on page 30.)

Reflected signal measurements made over a wide band of frequencies provide a much better picture of an antenna's performance than either pulsed TDR or narrowband VSWR readings. Thus, on- and off-frequency readings are important to demanding users as part of the installation and maintenance contracts for their antenna systems.

To get the full benefit of these measurements, the measuring instrument must be lightweight and battery-powered. It should be highly stable and accurate. It should be able to display measurements not only near zero, but with an RC value from 0.8 to 1.0 (9:1 to ∞ :1 VSWR).

Low-cost SWR analyzer and antenna match indicators do not have the frequency stability and measurement range to make adequate frequency domain measurements. Although inexpensive and portable, these instruments typically use printed dials or voltmeters to display the operating frequency. They lack temperature compensation on either the signal generators or the signal detectors. Their designs include no steps to compensate for detector diode non-linearities.

Professional installers are more likely to use a spectrum-network analyzer to make frequency domain measurements. When combined with an external reflection bridge, the spectrum-network analyzer can make precise frequency domain reflection measurements.

Nevertheless, these instruments are heavy and expensive. When used in the field, they may be subject to damage, and they may attract thieves.

A lighter and lower-cost alternative is the portable scalar network analyzer. (See Photo 1 above.) It combines an ultra-stable signal generator, frequency counter and reflection bridge in a battery-powered package. Although not as versatile as a spectrum-network analyzer, a scalar network analyzer is a strong choice for FDR measurements.



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How to use microwave waveguide

Basic information about microwave waveguide, connectors and other devices helps you to make economical choices of waveguide types and materials for radio communications backbone networks.

By Robert P. Williams

As more and more land mobile radio system operators use point-to-point microwave radio backbone networks, their need for waveguide transmission line increases. The following information is intended to help microwave network users understand the proper selection, installation and use of waveguide. Waveguide normally is a hollow-tube uniconductor with an air dielectric.

Most two-way radio and radiopaging systems use coaxial cable to connect radio equipment at frequencies as high as 1GHz. Coaxial cable has great merit as transmission line: low cost; wide band-

width; small size; easy installation; useful from dc to all radio frequencies; suitable impedance characteristics; and mechanical flexibility. Coaxial cable can be used outdoors with relatively long life, provided its outer jacket is of high quality and the jacket does not contaminate the dielectric. But at higher frequencies, coaxial cable's attenuation (signal loss) becomes a major concern.

The primary reason for using waveguide above 2.7GHz is that it provides minimum attenuation. Other factors making waveguide the transmission line choice at microwave frequencies include its:

- maximum power handling capability, which is especially important in radar applications.
- impedance-matching qualities, which keep voltage standing wave ratio

(VSWR, or return loss) to a minimum.

- long life, with a minimum amount of degradation.

Typical attenuation values in decibels per 100 feet, all at 4GHz, for various coaxial cable and waveguide configurations appear in Table 1 below. These figures show the improvement waveguide offers in comparison to dielectric and air coaxial cable.

A large number of waveguide sizes, corresponding connector flanges and other waveguide devices is available. Waveguide size is a function of frequency. Characteristics and tolerances, as well as standardization objectives, are documented well in the following standards and specifications:

- EIA—Electronic Industries Association, Washington, DC.
- DOD—U.S. Department of Defense, various departments (MIL-STD and MIL-SPECS).
- IEC—International Electrotechnical Commission, International and Foreign divisions.

Waveguide types

The cross-sectional shape of waveguide serves to describe its type. The inside dimension in decimal inches ($\times 100$) identifies rectangular and circular sizes. The inside dimension of waveguide has everything to do with the selected wavelength (and therefore the frequency) of operation. Elliptical waveguide sizes typically are identified by the lowest operating frequency in gigahertz ($\times 10$).

Table 2 on page 36 describes the three principle types of waveguide transmission lines: rectangular, elliptical and circular.

Rigid, straight guides in various

Williams is quality control manager at Gabriel Electronics, Scarborough, ME.

Table 1—Typical attenuation at 4GHz (4,000MHz) for various transmission line.

TYPE DESIGNATION	DESCRIPTION	ATTENUATION PER 100 FEET IN dB
RG-213	copper coax cable, solid dielectric	21.5
9913/9086 (RG-8 type)	copper coax cable, semi-solid dielectric	11.0
7/8-inch	aluminum coax (hardline), foam dielectric	6.8
1 5/8-inch	corrugated copper coax foam dielectric	1.9
1 5/8-inch	corrugated copper coax, air dielectric	1.6
WR-229	copper rectangular waveguide	0.81
WE-37	copper corrugated elliptical waveguide	0.78
WC-281	copper circular waveguide	0.37

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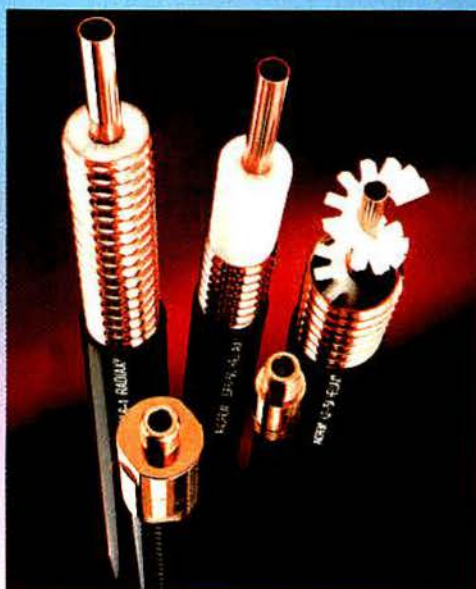
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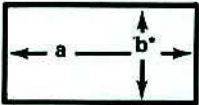
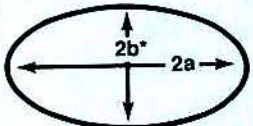
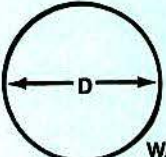
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Table 2—Waveguide type descriptions.

RECTANGULAR	ELLIPTICAL	CIRCULAR
<p>WR — waveguide, rectangular</p>  <p>WALL</p>	<p>WE — waveguide, elliptical</p>  <p>WALL</p>	<p>WC — waveguide, circular</p>  <p>WALL</p>
Examples of waveguide samples that might be used at 4GHz:		
WR-299 (a = 2.29 inches)	WE-37 (3.7GHz)	WC-281 (D = 2.81 inches)
Examples of waveguide sizes that might be used at 11GHz:		
WR-90 (a = 0.90 inch)	WE-108 (10.8GHz)	WC-109 (D = 1.09 inches)
*b ≈ a/2 (a is broad wall)	*2b ≈ 2a/2	
EIA Standard RS-261-B, MIL-W-85	manufacturer's catalog specifications	EIA Standard RS-200-A MIL-W-23068
MIL-W-3970 (general specification)		

length are commercially available for the typical communications frequency range of 1GHz to 26GHz. The waveguide size WR-650 has inside dimensions of 6.5 inches × 3.25 inches,

and size WR-42 has inside dimensions of 4.2 inches × 0.17 inch, for example.

Not all rectangular sizes have an inside-dimension aspect ratio of 2:1 because some early waveguides were

made of architectural brass tubing with outside dimensions of 2:1, broadwall-to-height.

Normal wall thicknesses, which typically are 0.080-inch for WR-650 and 0.040-inch for WR-42, are changed for special applications. "Heavy-wall" waveguide fits high-pressure, high-power applications. "Half-high" waveguide is used for restricted space applications. "Thin-wall" waveguide is used where weight limitations are imposed.

In addition to transmission line, rectangular waveguides are used in the fabrication of microwave devices, such as antenna feeds, directional couplers and coaxial cable-to-waveguide adapters.

Materials used in the fabrication of waveguides and considerations for each material are listed in Table 3 on page 38. Silver plating is used on waveguide intended for use where minimum attenuation is important. Otherwise, oxygen-free, high-conductive (OFHC) copper provides an economical alternative.

It is most important that the inside of any type of waveguide be smooth, clean, non-porous and dry to provide maximum performance and reliable long-term communications. Furthermore, dents or discontinuities cause poor VSWR and distortion.

Cleanliness and dryness can be ensured by pressurizing the waveguide with a dehydrator. For best results, the pressurized air's dew point should be kept below the lowest expected outside air temperature to avoid the formation of frost or condensation on the waveguide's inner wall.

Much of this discussion of rectangular waveguide applies to elliptical and circular waveguide, too. But it may be helpful to compare the merits and limitations of each type.

• *Rigid rectangular waveguide:*

(1) is used for transmission line and many microwave devices, including bends, twists and adapters.

(2) can be made in any custom length, as much as 20 feet.

(3) highly satisfactory VSWR (RL) and impedance-matching qualities.

(4) requires many connecting flanges on longer runs, with each flange being subject to RF and pressure leakage, and each subject to mechanical mismatches

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Table 3—Waveguide materials.

ALUMINUM ALLOY	COPPER ALLOY	COPPER (OFHC)
1100, 6061, 6063	'commercial bronze' 90% copper, 10% zinc	oxygen-free high conductivity
used for large waveguide or limited weight requirements	good for fabrication of microwave devices	excellent low attenuation, stable waveguide transmission line for rectangular, elliptical and circular guides. Highest conductivity, corrosion- resistant, widely used in industry.
reasonable compromise of electrical characteristics	strong and corrosion- resistant, but lower conductivity	
welded construction	easy to solder or brazed	

Example of WR-137 (7GHz) attenuation in dB per 100 feet:*

2.00 (1100 aluminum alloy)	2.32	1.56
-------------------------------	------	------

*MIL-HDBK-216, "RF Transmission Lines and Fittings," 1962.

that cause higher VSWR (lower return loss).

(5) has only *single* or *plane* polarization, and only *one* RF communication

frequency at a time may be propagated down the line. The field pattern of the guided wave is called *mode*.

• *Elliptical waveguide:*

(1) is popular because it is semi-flexible, it has a protective jacket and it is supplied in continuous lengths.

(2) as a semi-flexible transmission line, reduces engineering planning and installation time. It is delivered, pressurized and in rolls. Lengths greater than 1,000 feet are available, eliminating the need for interconnecting flanges.

(3) requires great care in handling and installation because one kink or dent could ruin the entire run.

(4) supports only one polarization, the same as rectangular waveguide. Two runs must be used for transmitting and receiving.

• *Rigid circular waveguide:*

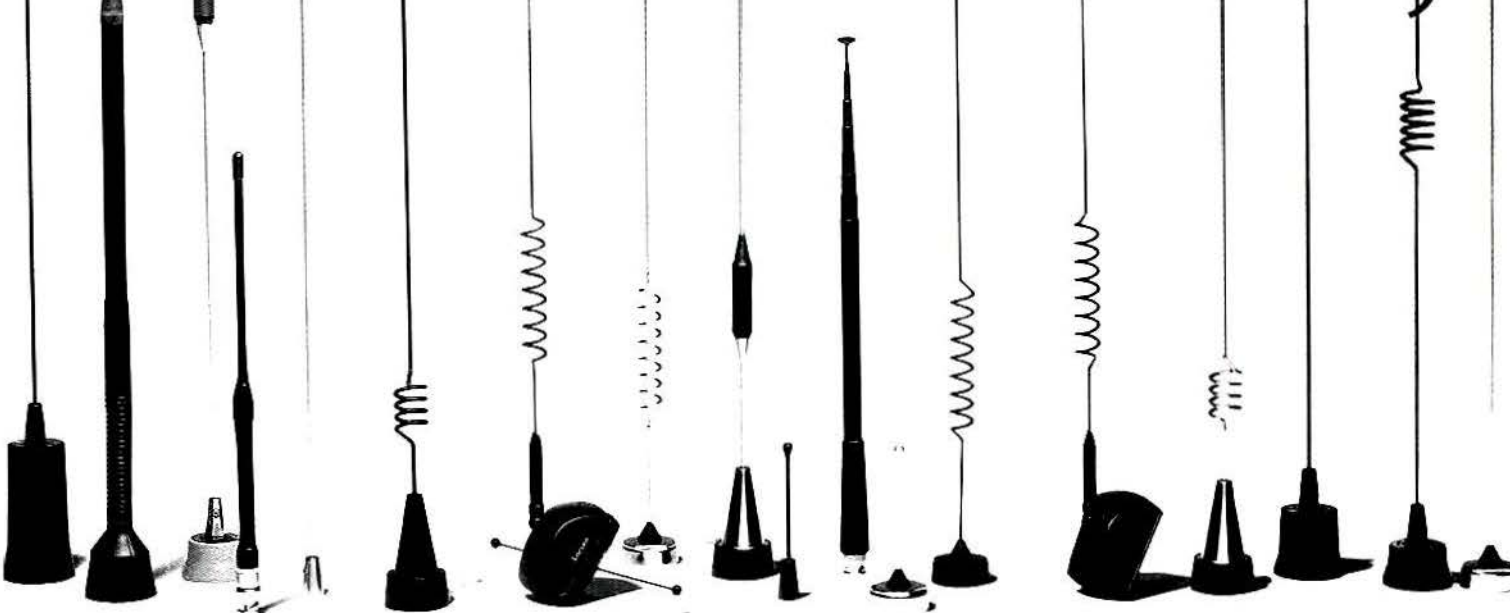
(1) comes in various lengths, as does rectangular waveguide.

(2) is the best choice for low attenuation. It is an excellent choice for extremely long runs.

(3) can be used for fabricating networks, duplexers, transitions and rotary joints.

(4) has the best transmission signal capacity, supports two polarizations and

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as many as three frequency bands simultaneously with maximum discrimination among them.

(5) may require many flanges. Section alignment of the inside wall is critical.

(6) has an inside diameter that must be manufactured to a tight out-of-roundness tolerance. Circular waveguide must be installed without damaging the cross-section to maintain discrimination between the two oppositely polarized signals.

- **Other waveguide types:**

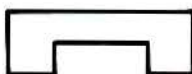
(1) *Flexible waveguide* uses convoluted, corrugated, interlocked or bellow walls to offer short, twistable sections. Flexible waveguide primarily is designed for reducing shock, vibration, expansion and contraction. Sometimes it is used *improperly* to connect misaligned waveguide sections.

Lengths of 1, 2 and 3 feet are common. Because flexible waveguide has higher losses than other types, as little of it as possible should be used.

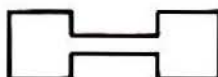
The connecting flanges on flexible

waveguide mate with rigid waveguide flanges. Heavy jackets on flexible waveguide offer the necessary protection. Excessive movement of the flexible waveguide can cause fatigue of the waveguide wall and deterioration of the electrical performance.

(2) *Ridge waveguide* is used for exceptionally broad bandwidth applications, but its attenuation is higher than for other types. Ridge waveguide has a lower impedance and handles less power than rectangular waveguide. Its name comes from its cross-sectional shape.



SINGLE



DOUBLE

Flange connectors

The connection between one section

of waveguide and another is made with copper alloy (brass) or aluminum flanges that are soldered, brazed, welded or threaded to the outside waveguide wall. To avoid corrosion, dissimilar metals usually are not connected on a waveguide run.

Flanges bolted together provide physical support for the waveguide. They *may* provide electrical contact and *may* provide a pressure connection. In any case, they always should self-align the inside walls of the two waveguides being joined together.

All waveguide flanges are identified by corresponding waveguide type sizes. They are grouped as "contact" (electrical) and "non-contact" (choke and cover) types.

Additionally, contact flanges are designed as "pressurized" (air-gasketed, e.g., CPR) or "non-pressurized" (e.g., CMR). Non-contact flanges are designed to work with both non-pressurized and pressurized transmission line systems.

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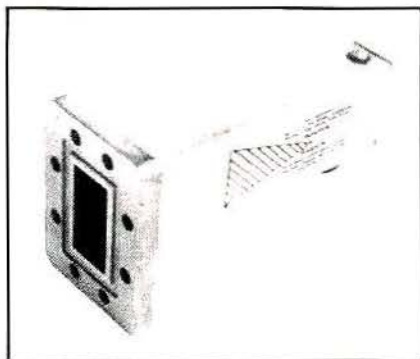


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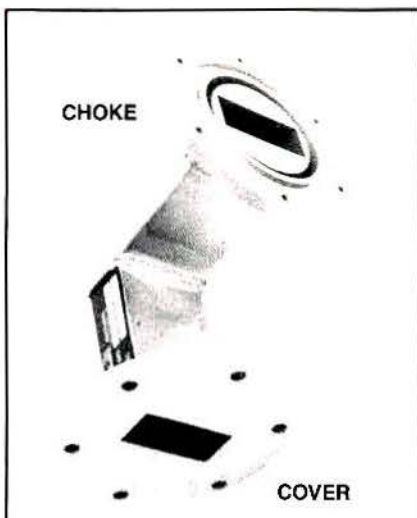
A grooved, contact, pressurized, rectangular (CPR) flange.

tems, including waveguide and antenna feeds, have dry air pressurizers attached to them to prevent moisture and dirt from degrading VSWR and increasing attenuation. Contact flanges for rectangular waveguide not used under pressure are called "CMR," which stands for "contact, miniature, rectangular." Pressurized rectangular waveguide contact flanges are called "CPR," which stands for "contact, pressurized, rectangular."

- **Contact flange**—With a contact flange, a mechanical contact surface provides the electrical contact necessary between waveguide sections. "Thru" contact flanges allow waveguides to be squarely butted together by machining off the two ends. The waveguide sections are tightly clamped together with bolts. If the waveguide sections are aligned carefully, reflections and RF leakage are kept to a minimum.

The pressurized style of contact flange contains a gasket groove on at least one of the mating surfaces. A gasket in the groove serves as a pressure seal.

- **Non-contact flange**—Electrical contact is not necessary with a non-contact flange combination. One flange, the "choke," includes a quarterwave-deep L-shaped cavity. When mated with the other flange, the "cover," another quarterwave cavity is formed, and the combination forms a halfwave shorted transmission line in series with the waveguide. Electrical contact is unnecessary because the RF short-circuit



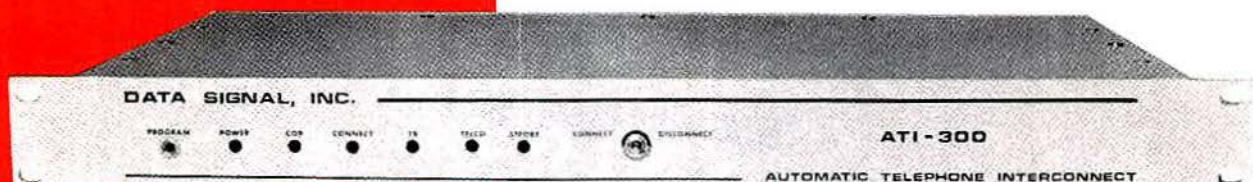
A non-contact choke-and-cover union guide (UG) flange.

presents zero impedance at the waveguide input. The contact coupling between the waveguides, using the choke-and-cover flange, may be less than perfect for acceptable performance.

The non-contact flange has a gasket

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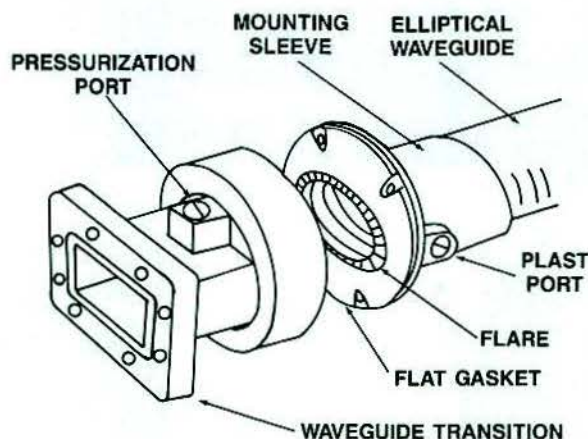
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Table 4—Copper alloy and aluminum alloy rectangular waveguide flange data.

Group	Contact			Non-contact		
Type	Pressure		Non-pressure	Pressure		
	<u>CPR</u>		<u>CMR</u>	<u>UG</u>		
Face Cross Section	Flat (F)	Groove (G)	Flat	Choke (2 Grooves)	Cover (Flat)	Cover/Gasket (Flat & Gasket)
Standards/ Specifications	EIA-RS-271-A and MIL-F-3922		EIA-RS-166 and MIL-F-3922	MIL-F-3922		IEC
Waveguide Mounting Method	Thru (sleeve) or Butt (raised corral) or, Socket (recessed)			Butt or, Socket	Butt or, Socket	Thru or, Butt or, Socket
Mates to	G or, F	F or, G	Itself	Cover or, Cover/Gasket	Choke or, Cover	Choke or, Cover or, Cover/Gasket



The interface portion of elliptical waveguide flanges is rectangular.

groove for a pressure gasket, in addition to the quarterwave slot (the cavity described above). If the gasket is made to conduct RF, it further reduces RF leakage at the flange connection.

Non-contact choke-and-cover flanges are known as "UG" flanges because they are defined by military standards and specifications. "UG/U" stands for "union guide/universal," with "union" meaning "connection."

Features of rectangular waveguide flanges typically used in microwave communications systems are listed in Table 4 above.

Circular waveguide flanges are covered by manufacturer and user specifications.

The interface portion of elliptical waveguide flanges is configured as rectangular and, therefore, is included in Table 4.



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Industrial (EIA) and military standards, along with manufacturer's catalogs, provide important sources of practical data. Some are summarized in the references that appear at the end of this article. Both EIA and MIL specs should be consulted. For example, rectangular waveguide operating at 3.95GHz to 5.85GHz is EIA WR-187, which is the same as MIL RG-49/U. Flanges that

could be used include EIA CPR-187F, CPR-187G and CMR-187; or MIL UG-149A (cover) and UG-148C/U (choke).

The technical understanding of waveguide has just been touched upon. In summary, though, here are a few of the important points:

Technical points

- (1) Electromagnetic energy has two

components, an electric field and a magnetic field.

(2) Many (an infinite number) possible electric and magnetic fields can exist in a waveguide as RF energy propagates through it.

(3) The configuration of the transverse electric fields is known as the "TE" mode, in which the electric field vectors are perpendicular to the direction of propagation.

(4) The configuration of the transverse magnetic fields is known as the "TM" mode, in which the magnetic field vectors are perpendicular to the direction of propagation.

(5) The particular mode transmitted within a waveguide depends upon the excitation employed and on the waveguide cross-section's size and shape in relation to the wavelength or frequency, as explained in MIL-HDBK-216, Sect. 6B, 12 June, 1975.

(6) Waveguide operates as a high-pass filter. For a given mode, frequencies above cut-off propagate, and lower frequencies (longer wavelengths) do not.

(7) The field configuration for the lowest cut-off frequency of operation is called the *dominant mode*.

(8) For the commonly used rectangular waveguide operating in the dominant mode (TE₁₀)*, the cut-off wavelength is:

$$\lambda_c = 2a = V_c/f_c$$

where

V_c = velocity of light

f_c = cut-off frequency

λ_c = cut-off wavelength

a = broadwall dimension

For example, for WR-187 waveguide:

$$a = 1.87 \text{ inches} = 47.55 \text{ mm}$$

$$V_c = 299.792 \times 10^6 \text{ m/sec}$$

$$\lambda_c = 2a = 47.55 \text{ inches} = 95.1 \text{ mm}$$

*The first subscript, "1," denotes the number of half-cycle variations in field intensity in the direction of the broadwall. The second subscript, "0," designates the number of half-cycle variations in field intensity in the narrow wall direction—in this "dominant mode" case, one and zero, respectively.

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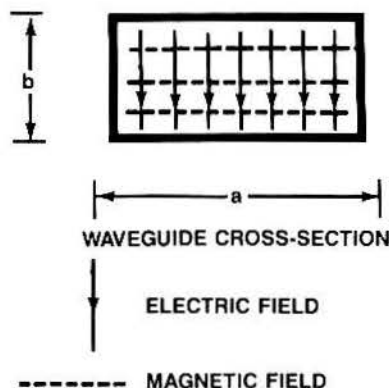
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$$\begin{aligned}
 &= 0.0951\text{m} \\
 f_c &= V_c/2a \\
 &= \frac{(299.792 \times 10^6 \text{m/sec})}{0.0951\text{m}} \\
 &= 3.152 \times 10^9 \text{Hz} \\
 &= 3.152\text{GHz}
 \end{aligned}$$

(9) Signal loss due to reflections may be of greater concern than attenuation losses. Discontinuities and mismatches in waveguide and connections cause reflections. Gradual variations are far less troublesome.

The ratio of the incident wave power (transmitted energy upon a discontinuity or load) to the reflected wave power upon the discontinuity or load is called "return loss." When these two waves add together, the result is a standing wave. The ratio of the two waves' maximum-to-minimum amplitude is called "standing wave ratio" (SWR). For the purpose of making calculations,



all discontinuities, loads and mismatches may be treated as impedance circuits. Thus, matching impedances becomes most important in reducing reflections in waveguide systems.

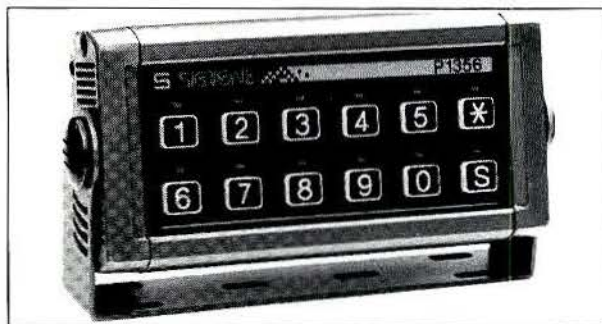
There would be no reflections, meaning the SWR approaches 1:1, if the waveguide transmission line had no impedance discontinuities and its characteristic impedance matched the impedance of the terminated load. Return loss (RL) is measured in decibels; SWR

usually is measured as a voltage standing wave ratio (VSWR).

References

1. EIA Standard RS-261-B, "Rectangular Waveguides."
2. EIA Standard RS-200-A, "Circular Waveguides."
3. EIA Standard RS-271-A, "Waveguide Flanges (Pressurized)."
4. EIA Standard RS-166, "Miniature Waveguide Flanges (Unpressurized)."
5. MIL-W-85G Specification, "Rigid, Rectangular, Waveguide."
6. MIL-W-23068 Specification, "Circular Waveguide."
7. MIL-HDBK-216, "RF Transmission Lines and Fittings."
8. MIL-F-3922 Specification, "Flanges, General Purpose, Waveguide."
9. Cablewave Systems, "Catalog 600."
10. Gabriel Electronics, "Catalog 871."

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Specifying carrying cases for portable two-way radios

Carrying cases protect portable two-way radio transceivers and make them available for quick use. These considerations will help you to balance requirements for protection, durability, economy, comfort and appearance.

By Edward C. Otrusina

Carrying cases are popular with portable two-way radio users because of the protection, attachment options and appearance.

► **Material**—Leather has been the preferred material for portable two-way radio cases since the first hand-held transceivers were manufactured.

In recent years, the use of cheaper, lighter synthetics, such as nylon and plastic, has increased.

Whether the popularity of synthetics will continue to increase is uncertain. Frank Rutland, technical director of the Leather Industries of America trade association, points out that 20 years ago, it was believed that synthetics would displace leather in the footwear market. It has not happened, mainly because in shoes as in accessory cases, it is difficult to duplicate natural leather's many useful properties.

Natural leather's handsome appearance helps to convey an image of strength, professionalism and authority that is especially important in public safety applications. A leather surface is easy to grip. Leather's flexibility and elasticity cushion the instrument against shocks and jolts. It resists heat and stays flexible when cold. It does not support combustion.

Special tanning and finishing give leather an admirable degree of water resistance without harming its natural ability to breathe. Synthetic cases may

Otrusina is president of A.W. Enterprises, Bedford Park, IL. He invented the patented Innovator swivel connector described in this article.

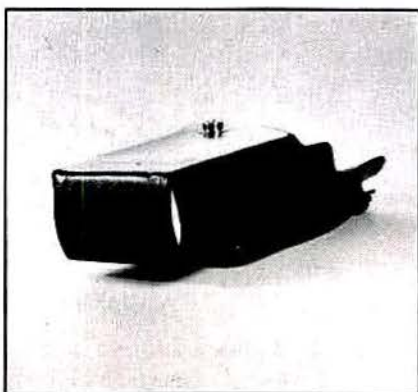


Photo 1. Foldover bottoms have a short life because weak points develop along the crease.



Photo 2. A separate piece of material secured with riveting and stitching creates a more secure and rigid bottom.

trap heat and moisture inside, causing problems with the radio. Other artificial materials, such as woven nylon, are too porous, offering little or no water resistance.

► **Hardware**—Rust prevention is an important consideration for snaps, rivets, D-rings and other hardware exposed to moisture, salt air and chemicals. Stainless steel rivets and nickel-

plated brass snaps offer high strength and high resistance to corrosion. Non-magnetic stainless steel rivets can be identified by their flat metal appearance. Nickel-plated steel snaps, which are prone to rusting shut, can be detected by their attraction to a magnet.

Rivets recessed in a counterbored area will not scratch the radio or make unwanted electrical contact. Rivets that compress the material weaken it and cause it to tear.

► **Bottom**—The basic design for a case bottom uses a leather flap extended from the front of the case, folded across the bottom and secured to the back. (See Photo 1 at the left.) This design creates stress points along the crease. The weight of the radio stretches the leather at the stress points and eventually makes it tear.

Riveting the bottom to folded side flaps helps, but it does not overcome the design's basic weakness.

A separate piece of leather riveted and stitched to the rest of the case provides the most rigidity, form, durability and protection. (See Photo 2 at the left.) Remember, if the bottom drops out of the case, so does the radio.

► **Back**—Most cases are formed from a pattern that is die-cut from a single section of material. This method eliminates all but one line of stitching, which holds the case together at the back.

Hard thread (as opposed to cotton thread) and zigzag stitching improve resiliency and durability. Stitches, spaced five to seven per inch, should be embedded into the leather to prevent snags, breakage and premature wear. You can tell if stitching is embedded by

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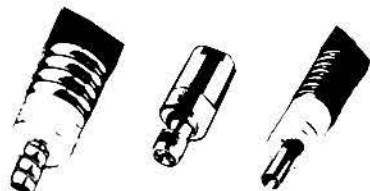
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moving a thread slightly and looking for a recession in the leather.

An extra panel of leather riveted in place reinforces the back, relieves stress on the seam and adds rigidity to the case. If this inner panel is omitted, the radio abrades the stitching and causes premature failure.

► **Corners**—Thin, narrow channels should be grooved in the inside of the pattern where it folds to form corners. The channels should stop just short of

Key considerations in case selection

- ☐ **Material.**
- ☐ **Hardware.**
- ☐ **Bottom.**
- ☐ **Back.**
- ☐ **Corners.**
- ☐ **Covers and holddowns.**
- ☐ **Belt attachments.**

the top and bottom edges to minimize tearing.

Channeling creates a case with sharp, attractive corners shaped tightly against the unit. Contorted cases and bowed corners not only look bad, they are weaker and prone to failure.

► **Covers and holddowns**—For maximum protection, use a full cover that encloses the unit except for speaker, microphone and control openings. The full cover can be fastened with snaps or hook-and-loop fabric (Velcro).

A leather T-strap is an economical way to retain the radio in the case while providing access to most control functions. A case with a string retainer or bungee cord works best for maximum control access.

Belt attachments

The simplest case permanently attaches to a belt flap. It cannot be detached without removing the belt. Snaps on the belt flap, a belt loop or both help to alleviate this inconvenience.

Swivel connectors attach the case to the belt more conveniently because they allow the case to rotate to a horizontal

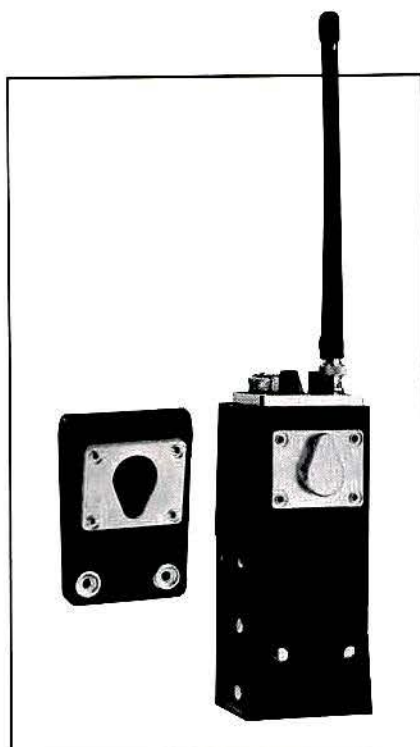


Photo 3. A quick-release swivel connector adds protection to the radio and comfort to the wearer.

position when the wearer is seated. This makes it more comfortable for people who enter and exit their vehicles frequently.

With a swivel connector, the radio quickly and easily detaches from the belt for use while still encased and protected.

Swivel connectors attach in three ways: drop-in, insert or clip-in. When attaching a drop-in swivel connector, the operator must invert the case 180°, maneuver it above the socket and down into it. An insert swivel connector allows the inverted plug to be pushed directly into the socket. The clip-in swivel, which attaches from any direction, reduces the risk of dropping the radio by eliminating the maneuver to invert the case. Examine samples of all three devices, and specify the swivel that best meets your organization's needs.

Any belt attachment should hold the case close to the body where it is less likely to bump against objects. A quick-release swivel connector shown in Photo 3 above is formed of strong, cold-rolled steel with a corrosion-resistant coating. It is 0.25-inch thick and holds the case safely and comfortably close to the body.

The Best Got Better

Zetron added extra features to make the ZMX the absolute best choice for your mobile radio.

Backlit Keypad

Each key on the ZMX is uniformly illuminated by its own LED. Your user will not only be able to see the keys in a darkened vehicle but will also be impressed by the professional backlighting — and that's especially important if you compete against cellular systems.

Plug-and-Go Installation

The ZMX is designed for the quickest, cleanest installation possible. Simply plug in the microphone and it's ready to operate on most mobile radios. You don't even have to open the case or modify the radio.

Cellular-Style Dialing Mode

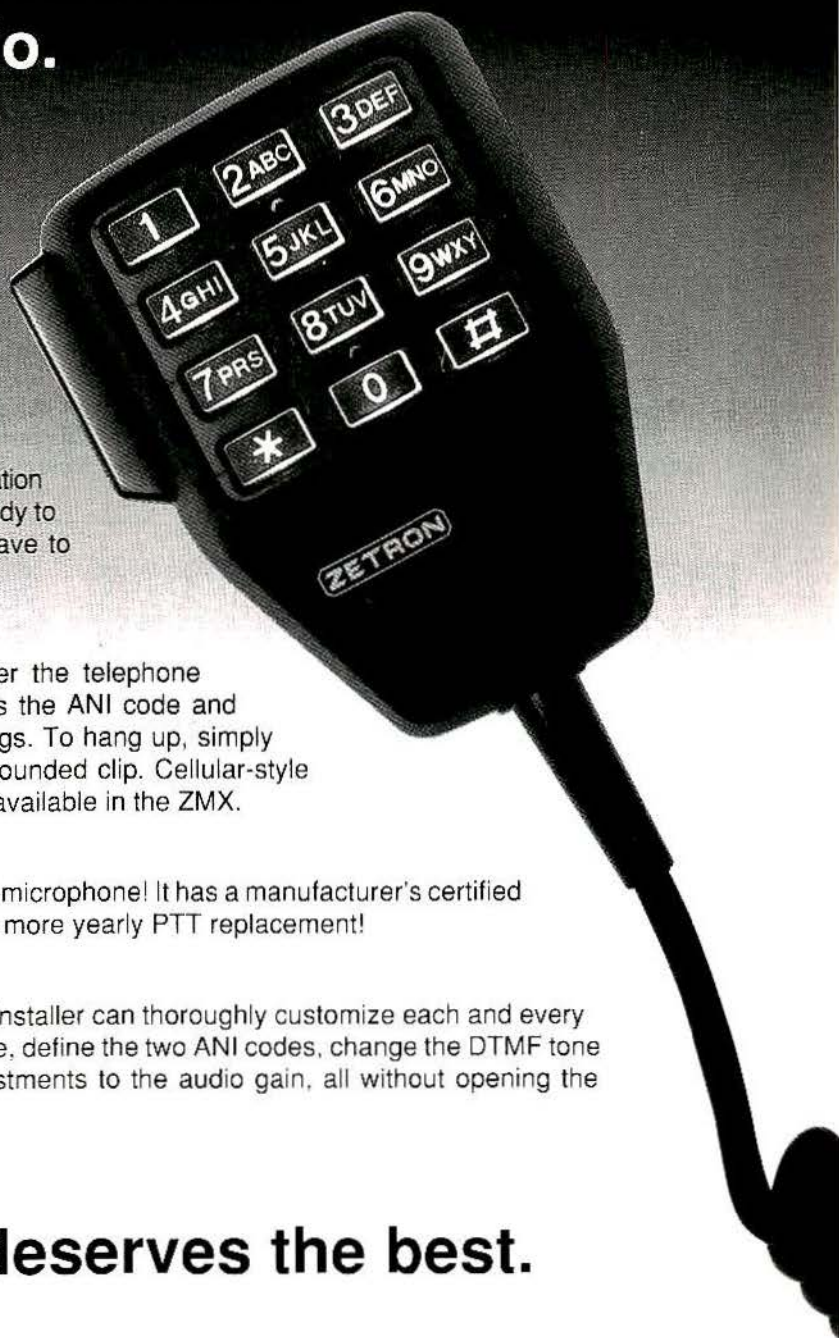
The ultimate in dialing convenience! Simply enter the telephone number and press the * key. The ZMX transmits the ANI code and telephone number automatically, with proper timings. To hang up, simply press the # key or return the microphone to its grounded clip. Cellular-style dialing is just one of six convenient dialing modes available in the ZMX.

30-Million-Cycle PTT Switch

You never have to replace the PTT switch in a ZMX microphone! It has a manufacturer's certified lifetime rating of 30 million uses without failure. No more yearly PTT replacement!

Fully Programmable from Keypad

By entering simple commands on the keypad, the installer can thoroughly customize each and every function of the ZMX. Imagine: select a dialing mode, define the two ANI codes, change the DTMF tone duration and spacing . . . even make rough adjustments to the audio gain, all without opening the microphone's case!



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Circle (45) on Fast Fact Card

EMCI: Specialized mobile radio industry growth slows in '91; economy plays a role

The SMR industry continued to grow in 1991 at a slower growth rate, according to Economic and Management Consultants International (EMCI), Washington, DC.

The market research firm determined slower U.S. economic growth translated to slower growth in the SMR industry. The third quarter of 1991 was particularly weak, "The State of SMR: A

Look at SMR and the Private Radio Industry" report shows.

The installed base rose about 130,000 units in 1991, a 13% growth, the report states. This is the smallest number of units added since 1986.

EMCI predicts 1992 growth to be 150,000 units added, but only if the economy turns around the later part of 1992.

The long-term outlook is for approximately 2 million SMR units in service by 1996.

EMCI conducted its research in conjunction with the American Mobile Telecommunications Association (AMTA), a Washington, DC-based trade association that represents the SMR industry.

Intertec expanding, moving to larger corporate office effective May

Intertec Publishing, publishers of *Mobile Radio Technology*, *Cellular Business*, *Cellular & Mobile International* and other trade publications, is relocating due to continued growth. The company currently operates out of six locations in Overland Park, KS, and has been in its main building since 1969. The move is expected in May.

The consolidated, new corporate offices will be at 9800 Metcalf Ave.,

Overland Park, KS 66212-2215; telephone 913-341-1300. The five-story building will be named the Intertec Building.

"This move exemplifies the growth pattern experienced for the company over the past five years," said Jack Hancock, president. "It allows us to bring together many of our employees under one roof, and this provides the opportunity for the natural synergies among

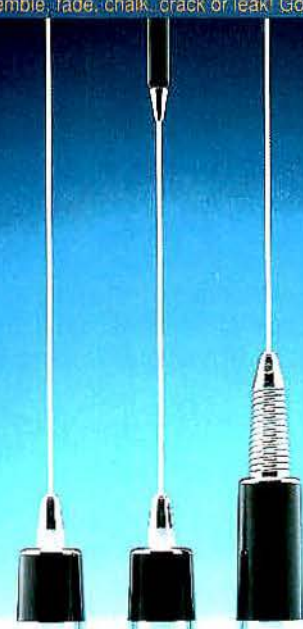
our magazines to prosper."

Intertec was founded in 1886 and publishes 24 magazines, five newsletters and more than 250 technical books and pricing guides, along with a number of other related publications and products. Divisional offices include Chicago, Detroit, Minneapolis, New York City and White Plains, NY.



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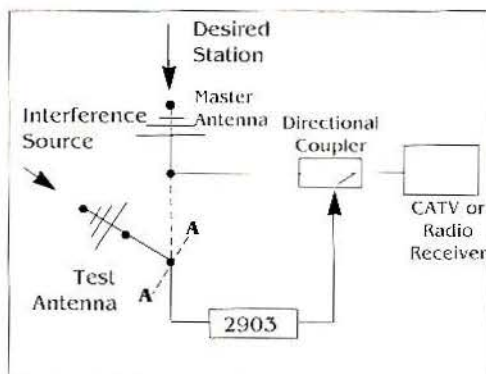
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Phase Canceled applied to suppressing interference at CATV systems or radio receiving sites with distant interference source.

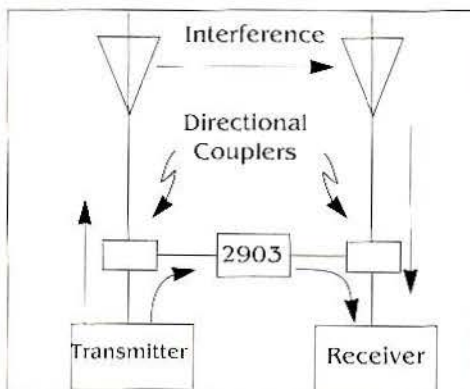


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680-890



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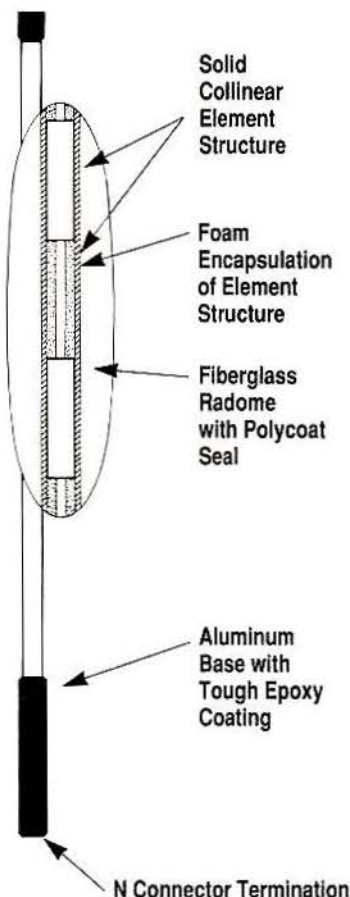
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ACT update

Council sets up regional chapters

By Thomas Green

Because many technicians have expressed the desire to meet other technicians in their same geographical areas, the Association of Communications Technicians (ACT) volunteer leadership council is continuing its efforts to organize informal local chapters.

Many technicians are unable to travel to the National Association of Business and Educational Radio's (NABER) Annual Mobile Communications Conference and other national conventions.

With the institution of local chapters technicians would be able to network, exchange current technical information and attend important training sessions. No longer will technicians miss out on the vital activities and opportunities that occur at national conventions. Local ACT chapters would be able to address many of the unique needs of technicians in a given area.

Green is a communication electronics instructor at Ranken Technical College in St. Louis and ACT's leadership council chairman. ACT is a membership section of NABER.

Organizing a local chapter is challenging because the average distance between members is greater than 50 miles, which means most technicians must travel a considerable distance to attend a meeting.

Because many technicians work more than 40 hours per week, it is difficult for them to find time to attend.

Two other important challenges in developing local chapters include locating a meeting site and obtaining the necessary funding to conduct the meetings. We are developing specific proposals to address site selection and finances.

Although logistical problems must be worked out, establishing informal local chapters is an excellent way to confront and deal with unique regional needs of ACT members.

We are confronting these problems head on, and we have begun to organize the first ACT local chapter in the St. Louis area. We hope to have the first meeting in the spring.

If you are interested in attending the St. Louis chapter meeting or if you would like to establish a local ACT chapter, call member relations specialist Dorena Bertussi at 800-759-0300.

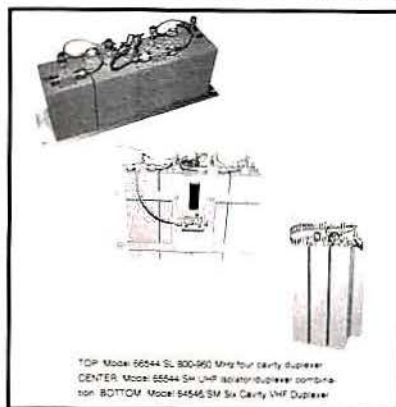


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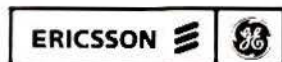


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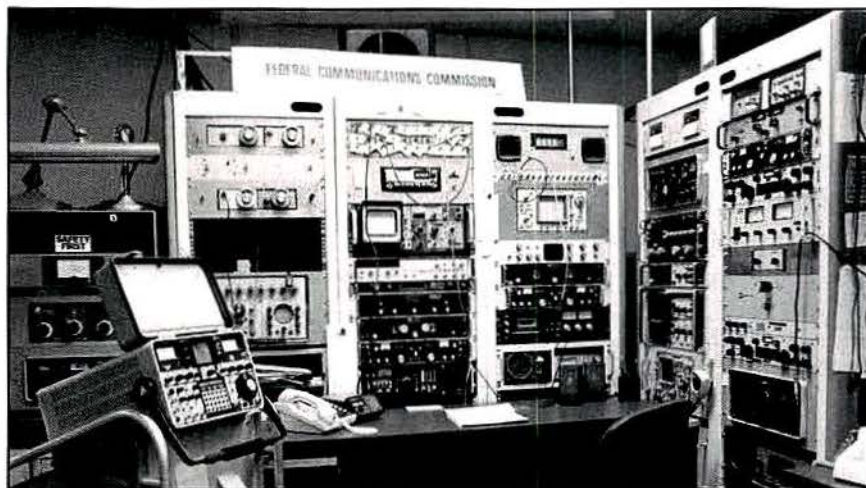
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Circle (51) on Fast Fact Card

Failure to identify is major problem in land mobile service



The FCC's San Diego listening post monitors interference.

FCC Field Operations Bureau electronics engineer Jerry Man, who works in the agency's San Diego office, said that a major problem in the land mobile radio services is that many properly licensed users fail to comply with sta-

tion identification rules.

"Most people are not aware of why the commission requires station identification," he said. "It is not because we wish to impose our presence on a particular service. The main reason for re-

quiring this identification is safety."

Man explained that any transmitter is capable of transmitting a signal on a frequency other than its assigned frequency, going off-frequency, generating a spurious emission, generating an improperly attenuated harmonic and playing a role in generating an intermodulation product. These unwanted signals may interfere with safety services such as police, fire and medical communications.

"If there is an identification to be heard when we monitor the signal, it can shorten our response time and maximize our resource allocation. And that is the most important thing."

The day before Man was interviewed, his office handled two such interference cases involving police communications.



Jerry Man

"We cover a rather large territory with minimal resources," he said. "If radio communications service companies and private system operators want to help us to do our jobs so we have

more time to work on any interference complaints they may have, the best thing they can do is to use their call signs."

Man said he visited a northern San Diego radio communications site a few weeks before the interview and found several land mobile radio licensees operating from the mountaintop. He found several interference problems at the site. Resolving those problems was hindered not only by the lack of station identification but by failure to post license documents as well.

"Licensees are required to post license documents at their base stations," he said. "Without the license information on site, it takes a lot of time to track down the information we require: who the user is, the authorized RF power output, the antenna orientation and several other factors."

Man said the two most important steps licensees can take to help the FCC to control interference are to identify their stations by using their call signs and to post their licenses at their base stations.

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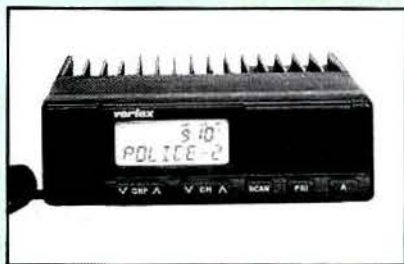
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99-channel mobile radio offers PC programmability



The Vertex 99-channel mobile features wideband frequency, computer-controlled operation, PC field

programmability, user-programmable functions, programmable time-out timer, busy-channel lockout and built-in CTCSS. The Yaesu mobile also boasts permanent electronic serial number; eight-character alphanumeric display; preprogrammed priority, user and multiple group scan modes; built-in two-tone, five-tone, DCS, DTMF and ANI signaling; and programmable alarm settings.

Circle (515) on Fast Fact Card

Security kit for portables carries whispers clearly



The SK-3 security kit for covert operation of a two-way portable provides clear transmission of whispered conversations. The Dynatech Tactical Communications set boasts overmolded strain reliefs at cable connection points for increased reliability. The kit can be used with the wireless earphone option.

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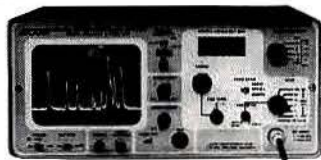
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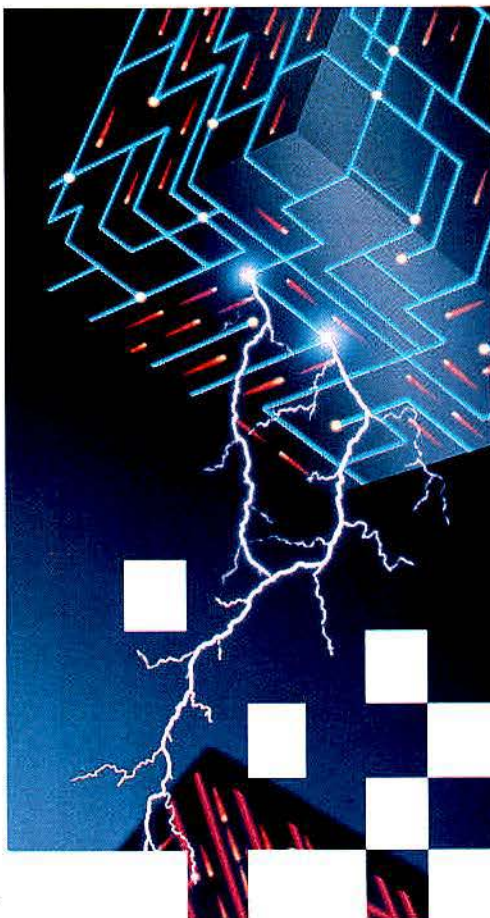
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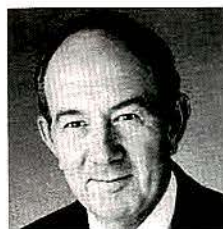
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Luncheon Keynote Speaker
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Chairman, FCC



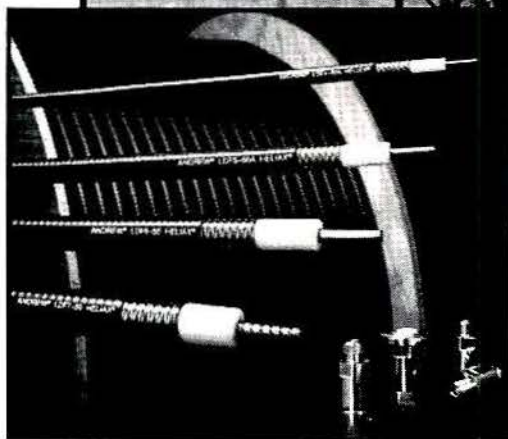
Luncheon Keynote Speaker
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Dinner Keynote Speaker
Craig McCaw
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Circle (446) on Fast Fact Card

Synthesized portables permit high, low power operation

The SP-2000 series synthesized portables offer a 1W or 5W selectable power switch; 10 channels; a 600mAh rechargeable battery; and die-cast aluminum chassis. The **Maxon** portables come in VHF, model SP-2550; and in UHF, model SP-2850.

Circle (416) on Fast Fact Card

Portable cradle fits hand-held, trunked radios

Model 610PC universal portable cradle from **SMC Electro-Mount** fits most hand-held portables, two-way trunking radios, walkie-talkies and portable CB units. The cradle fits the company's standard pedestal mounts.



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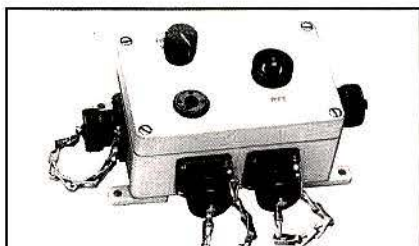


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New products

Radio interface module connects radios, intercom

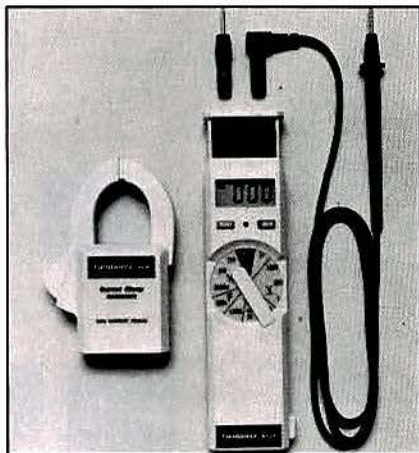


Model U3813 radio interface module allows headsets for portable radios to be used with the series 3800 intercom system from **David Clark**. The module features a PTT switch, listen level control and headset jack.

Circle (286) on Fast Fact Card

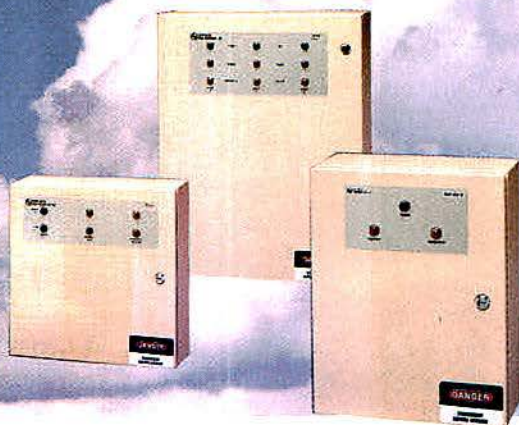
Digital multimeters boast voltage checker function

The heavy-duty line of multimeters from **Fieldpiece Instruments** includes digital multimeter, voltage checker and current clamp meter functions. The meters withstand 1,000Vdc and transients to 6,000V on any voltage range. A current clamp accessory converts the DMM to a digital current clamp meter.



Circle (207) on Fast Fact Card

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Circle (58) on Fast Fact Card

Portable radio receives Factory Mutual rating

The MPI II portable radio from **Ericsson GE Mobile Communications** provides intrinsically safe operation in Class I, Division I, groups C and D, with its Factory Mutual approval.

Circle (394) on Fast Fact Card

Coaxial connectors meet commercial applications

The RFX line of coaxial connectors from **Amphenol RF/Microwave Operations** features high quality and low cost. Popular connectors in the line, up to a maximum quantity, are available with a 24-hour delivery time.



Circle (349) on Fast Fact Card

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New products

1,000-channel receiver has 26 front-panel keys

The 1,000-channel mobile/base receiver from **Ace Communications** covers 500kHz to 1,300MHz. The radio has 26 front-panel keys for programming, and all information is stored in permanent memory.

Circle (377) on Fast Fact Card



Portable radio earphones ensure privacy



The CN series earphones from **T.E.A.** permit users to monitor receive signals with privacy, as well as enable transmissions to be heard in moderate-to-high ambient noise. The earphones plug into most portable radios.

Circle (407) on Fast Fact Card

EXCEPTIONAL WIRELESS TELEPHONE PRODUCTS

DataCom's PhoneLink/DataLink



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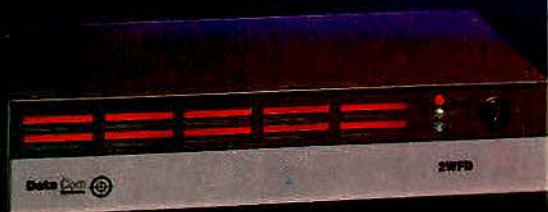
If you have ever had trouble with an RF telephone or data link, you know what a frustrating experience that can be. Even the manufacturer can't provide reliable test methods to users that don't have a 2-way shops worth of equipment.

- * **Take the trouble out of trouble shooting.**

DataCom's FD line of equipment has enough front panel diagnostic indicators that pinning down the source of trouble can be reduced to seconds.

- * **Ongoing support.**

DataCom's service and support lasts long after you have made the purchase. As a matter of fact, we're so confident in the quality and workmanship of our equipment that we offer a 30-day full money back guarantee.



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24-Hour Technical Support Available

Circle (80) on Fast Fact Card

Radio control operates with voice-grade channel



Model 428 PC-controlled remote radio control system from **Raven Electronics** contains an audio interface and control functions for remotely located AN/GRC 171, AN/GRC 211 and similar radios. The remote control unit provides audio, alarm monitoring and relay control via a single voice-grade channel. The radio control functions and relays are controlled by an IBM PC or compatible unit. The PC software is menu-driven. The radio control system is expandable to control 252 radios located at 63 remote sites, with each site equipped for 16 alarm points and eight control points.

Circle (284) on Fast Fact Card

Lightweight portables span ranges to 2 miles



Circle (258) on Fast Fact Card

Digital combiner tunes cavities automatically

A digital combiner from Allgon System works with a variety of existing combiners to tune cavities automatically to desired transmitting frequencies. It works with coaxial, waveguide or dielectric combiners. The combiner autotuning system works autonomously upon RF energy at the inputs, and it remains active for retuning cavities to compensate for drift variations. The unit boasts a modular design and accommodates a variety of racks and frames. It can be used with additional modules to form an unlimited number of channels for the transmitter antenna.

Circle (262) on Fast Fact Card

Fixed attenuator kits come in carrying case

Fixed attenuator kits are available in 50 Ω and 75 Ω impedances. The JFW Industries kits include feed-through terminations, matching pads and adapters.



Circle (210) on Fast Fact Card

The Spirit FM portable radios cover ranges to 2 miles and are available from Motorola. Spirit I weighs 12 ounces and offers 1W output and 1 VHF channel with a removable NiCd battery that can be charged in the unit by using a supplied plug-in unit. Spirit II one-channel portable is available in UHF or VHF

and has the ability to screen out unwanted conversations. Spirit III two-channel hand-held comes in UHF or VHF and accepts audio accessories. Spirit II and III have a removable battery that can be recharged in the unit or with a small desktop battery charger that is included with the radios.

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Circle (61) on Fast Fact Card

New products

Single-point ground panel comes in aluminum or copper

A single-point ground panel for lighting protection products from **Poly-Phaser** is available in aluminum or copper material with painted plywood

backing. Each unit comes with the necessary hardware for attachment to concrete, cinder blocks or 16-inch center stud construction.

Circle (417) on Fast Fact Card

Compact VHF mobile offers 40W, 6 channels

Model SLV40 1 1/2-inch thick compact VHF mobile handles 40W output and six channels. The **Relm** mobile has automatic squelch, die-cast frame, eight LED displays, and built-in CTCSS, DCS and two-tone sequential decode.



Circle (425) on Fast Fact Card

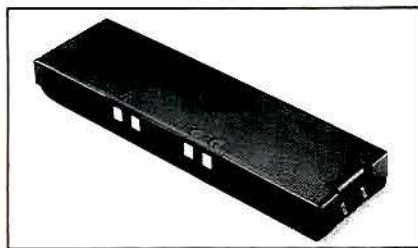
Vox headset features electret mic

The H7240 Vox noise-attenuating headset works with all portables to provide hands-free operation. The headset has a boom-mounted noise-canceling electret mic, and the Vox is included in the headset. The **David Clark** Vox unit is powered by an external rechargeable NiCd battery, and the headset will not drain power from the portable radio.



Circle (287) on Fast Fact Card

Replacement batteries fit cellular telephones



Replacement batteries are available from **W&W Associates** for cellular telephones. These include:

□ WP-310-1031A for the Mitsubishi 1500TPK transportable and the Diamontel 92 transportable.

□ WP-470-825 6V, 600mAh and WP-470A-825 6V, 900mAh for NovAtel's PTR 825 phone.

□ WP-416-100 7.2V, 750mAh/800mAh for the Nokia-Mobira Cityman 100 cellular telephone. A 7.2V battery eliminator is available. WP-417-100.

Circle (423) on Fast Fact Card

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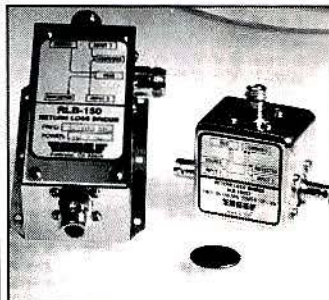
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Return Loss Bridges are a low cost solution for swept SWR measurements. These bridges can be used with a spectrum analyzer/tracking generator or service monitor. Being a self contained unit, no external attenuators, amplifiers, comparators or detectors required.

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FREE application note, "Understanding the Return Loss Bridge", call and ask for it!

Application note covers the uses of return loss bridges such as: tuning antennas, receivers, cavities, duplexers, isolators, and pre-amps; fault location in transmission lines and multiple bay antenna systems; measuring impedance and structural return loss of coaxial cables. This note also discusses the relationship of VSWR, return loss and reflection coefficient in basic, simple to understand terms.

Following units are available from stock:

Model	Freq Range MHz	Directivity	Price
RLB150B1	.040 to 150	50 dB	\$259.00
RLB150N3A	5 to 1000	35 dB	\$289.00
RLB150N3B	5 to 1000	45 dB	\$349.00
RLB150N3C	5 to 1300	45 dB	\$395.00
RFT050NM2	DC to 3000 reference	40 dB	\$125.00
CIS050N2	Matching cable sets 2 ft	NA	\$ 40.00

Note: When purchased with a bridge the RFT050NM2 and CIS050N2 are \$95.00 total

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Circle (62) on Fast Fact Card

In-house paging system supports 6,200 units



The PageOne in-house paging system supports as many as 6,200 units when it is used in conjunction with a private carrier paging provider. The unit is a combination effort of **Shinwa Communications of America** and **CSI**. The paging system offers hot-key pop up al-

phanumeric PC paging via IBM PC or compatible; dial-access paging; local control via DTMF telephone; and POC-SAG, Golay, two-tone, 5/6 tone, tone-only, tone-and-voice, talk-back and DTMF formats.

Circle (362) on Fast Fact Card

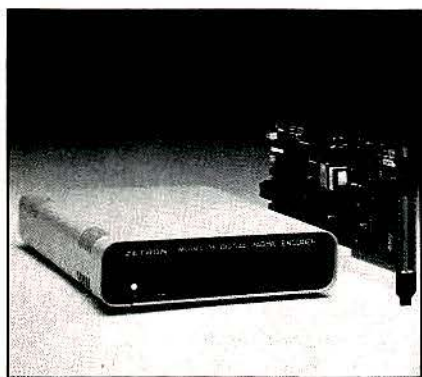
Soldering station features dual wattage control

The UTC SS soldering station allows dual wattage control with a selectable 21W or 35W function. The **Ungar** unit includes a fully grounded tip; a power base with built-in controller; anti-slip handle; and coil-spring iron holder with a ceramic mouthpiece.



Circle (328) on Fast Fact Card

Alphanumeric encoder comes in two versions



Model 16 alphanumeric paging encoder from **Zetron** comes in a stand-alone desktop version or as a circuitry card for an IBM-compatible PC. Model 16 accepts pages from typical entry devices such as a PC, CRT or a laptop-sized alphanumeric entry station.

Circle (402) on Fast Fact Card

UNDER-COVER



It doesn't matter what kind of surveillance vehicle you drive — if you need **total disguise** for your two-way radio system, **STI-CO** offers more than 250 antenna models in over 50 body styles.

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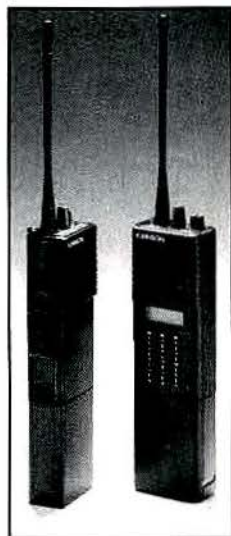
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Circle (86) on Fast Fact Card

New products

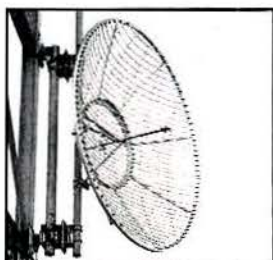
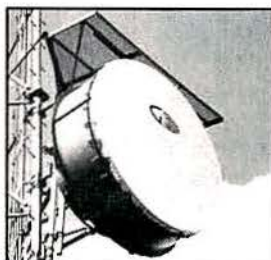
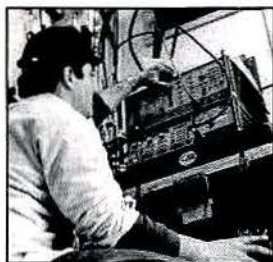
UHF hand-held transceiver operates in dual modes

Model 5876 UHF logic trunked radio from E. F. Johnson operates in trunking and conventional dispatch modes with as many as 10 systems, 10 groups and 100 conventional channels. The hand-held includes dual priority scan; alphanumeric LCD with status indicators; and system control via selector knob or front-panel keypad. The hand-held meets military standard 810C and D.



Circle (296) on Fast Fact Card

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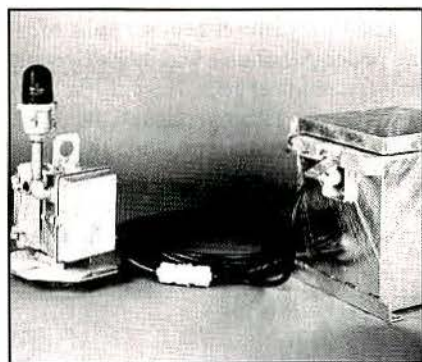
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Circle (65) on Fast Fact Card

Obstruction lights suit tower construction phases



Two models of temporary obstruction lights are available for use on towers under construction and can be used for permanent installation at remote sites. Model OB-30 features an FAA L-810 steady burn obstruction light with controls; mounting plate; 200 feet of 10/2

cable with twist connectors; 24Vdc, 90Ah battery bank with sealed, low-maintenance batteries; and automatic three-stage charger connected to a permanent 110 male outlet with weatherproof cover. Model OB-28 has a non-FAA flashing Xenon strobe with power supply; mounting plate; 200 feet of 10/2

cable; 24Vdc, 90Ah battery bank with sealed, low-maintenance batteries; and automatic three-stage charger connected to a permanent 110 male outlet with weatherproof cover. The **Hughey & Phillips** lights are available with optional solar arrays.

Circle (292) on Fast Fact Card

Replacement batteries fit cellular telephones

Replacement batteries are available from **Alexander Batteries** for various models of cellular telephones. Products include:

□ CL0612 7.5V battery with 700mAh capacity for Nokia-Mobira 612 cellular telephones.

□ CL0002 6.3V, 700mAh battery for Fujitsu's Pocket Commander phone; and CL0003 6.3V, 400mAh slim battery for Fujitsu's Commander phone.

□ CL9014 6.3V, 600mAh battery replaces Oki's RP9014/64-20001; CL9019 6.3V and 750mAh battery replaces Oki's RP9019/64-20002. A 6.3Vdc battery eliminator, model BE0914, powers Oki's 900 portable from a vehicle's cigarette lighter.

□ CL99-XT 6V, 600mAh replaces Diamondtel's HCBP-99 battery; CL3000-XT 6V, 600mAh replaces Mitsubishi's FZ978A battery.

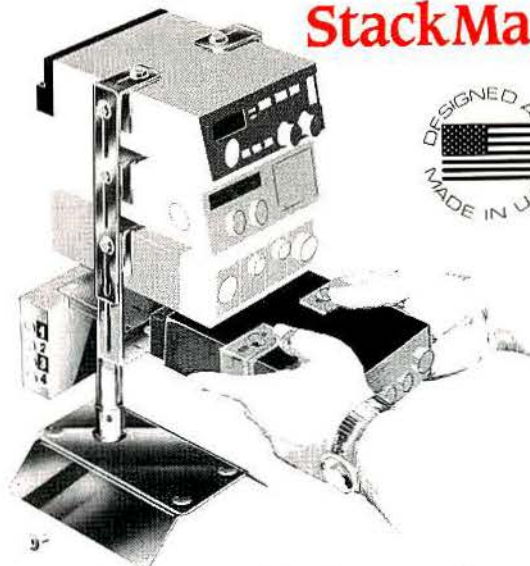
Circle (288) on Fast Fact Card



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Circle (66) on Fast Fact Card

New products

Radio control console includes 10 lines



Model C-5112 10-line and four-frequency radio control console from

Vega operates half-duplex over two-wire or four-wire lines and operates duplex over four-wire lines. The console includes two speakers and volume controls to independently adjust selected-line and unselected-line audio levels. The tone-format console converts any of the 20 lines to dc control with external adapters. The console's four DIP-switch programmable function tones may be used in an FI-F4 or paired configuration.

Circle (409) on Fast Fact Card

High-power terminations offer 50Ω impedance

High-power terminations from JFW Industries come in 1W, 5W, 30W, 50W, 100W, 200W and 300W power levels. The terminations are available with N, BNC, TNC or SMA connectors and offer 50Ω impedance.

Circle (381) on Fast Fact Card

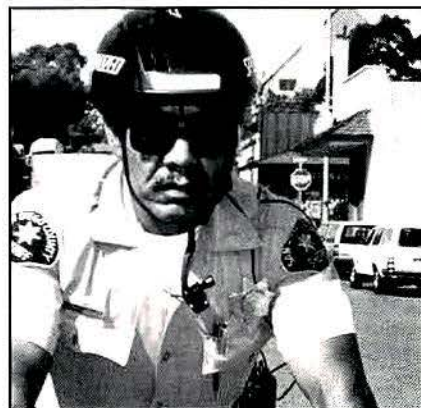
Solder cream kit enables SMT component repair

The solder cream kit from ESP includes solder cream alloy, fine pitch and water-washable flux systems. The kit contains molded dispensing tips and a reusable hand dispenser for dot or stripe applications.

Circle (387) on Fast Fact Card

Bicycle patrol headset mic clips to user's shirt

The Fast Comset headset suits bicycle police patrol uses and includes a mic that transmits even a whisper like normal speech. The mic clips to the user's shirt front, and the earphone fits under all bicycle helmets. The **Television Equipment Associates** headset is built to withstand abusive handling inherent in police field work.



Circle (424) on Fast Fact Card

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Circle (67) on Fast Fact Card

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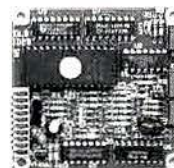
- 40 to 1000 Mhz tuned to your frequency
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Typical rejection:

± 600Khz @ 145 Mhz: 28db	
± 1.6 Mhz @ 220 Mhz: 40db (44db GaAs)	± 20 Mhz @ 800 Mhz: 65db
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Model ID-2B

The ID-2B provides required station identification without troublesome diode programming. The "ID over voice inhibit" circuitry allows for courteous operation by not allowing an ID until the next squelch closing.

ID-2B Wired/Tested \$99.95

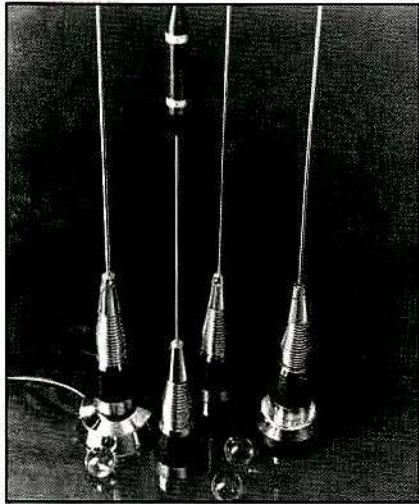
ID-2B-LP Low Power \$109.95

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Circle (68) on Fast Fact Card

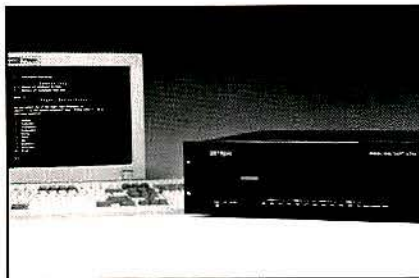
VHF, UHF antenna line exalts high durability



The Pro-5000 line of VHF and UHF antennas includes 22 models with 3dB gain VHF and 3dB and 5dB gain UHF models. The antennas incorporate three O-rings, hand tuned-and-tested conical coil and stable soldered connections. The **Antenna Specialists** models have a maximum VSWR of 1.5:1.

Circle (405) on Fast Fact Card

Paging terminal provides digital voice storage



Model 640 Dapt-Xtra dial-access paging terminal suits smaller paging service providers, as well as in-house paging systems. The **Zetron** terminal includes digital voice storage, voice prompts and simultaneous processing of multiple telephone inputs. The terminal offers two telephone inputs, remote transmitter control with 16 addresses, talkback paging, 1,500 subscriber capability and compatibility with popular analog and digital paging formats.

Circle (401) on Fast Fact Card

Software enhances engineering design

Cellular Engineer desktop engineering software package suits cellular planning and design engineers needs. It contains the software needed for switching, traffic engineering, trunking, RF and power engineering. **Radio Survey Master** is a real-time, multichannel radio field-strength and statistical analysis tool

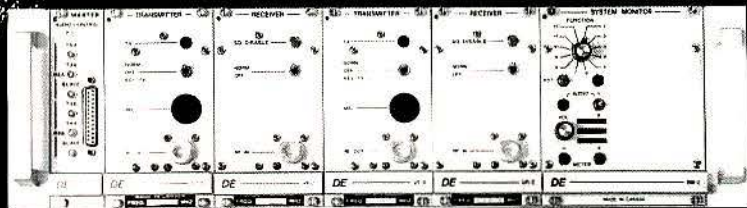
for RF engineers to use for conducting radio surveys. Using a IBM PC or compatible, the software is ideal for cellular, paging and mobile surveys. Both packages are available from **Quantum Publishing**.

Circle (501) on Fast Fact Card

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Circle (69) on Fast Fact Card

New products

Trunked radio system serves 16,000 IDs, 2,000 talk groups

The StartSite two-way radio trunking system for single-site users requiring as many as five communications channels handles 16,000 IDs and 2,000 talk groups. The Motorola trunked radio system comes in continuous control channel and selectable control channel

configurations. The continuous control channel package includes a dedicated control channel, as well as "emergency" and "PTT ID" as standard. The selectable control channel allows a choice between active control channel and dynamic control channel.

Circle (372) on Fast Fact Card

Dissipator element complies with UL96 standard

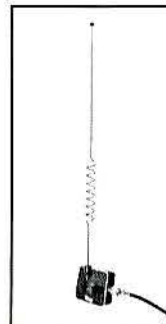
Model ALS-1000 dissipator element from Lightning Prevention Systems complies with the UL96 standard and is listed as class II modified air terminal.

Circle (383) on Fast Fact Card

Glass-mount antenna boasts fast install time

The APD853.3 glass-mount antenna from Antenna Specialists boasts a fast installation. The 3dB gain cellular antenna includes a one-step closed-cell foam tape mount and a detachable 15-foot RG58/U cable for simple vehicular cable routing. The antenna is rated at 10W with VSWR of less than 1.9:1.

Circle (404) on Fast Fact Card





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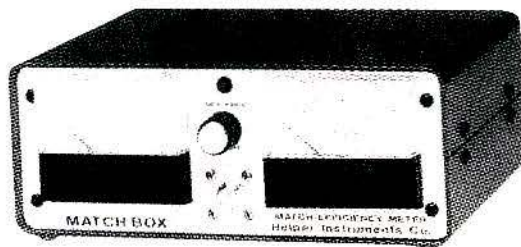
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Circle (70) on Fast Fact Card

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Circle (71) on Fast Fact Card

Trailer tower incorporates insulated equipment shelter



Model TM-51-35-S trailer tower from **Aluma Tower** comes with an insulated 4' x 6' x 6' equipment shelter. The shelter is available with heat, air conditioning, ventilation, electrical power and storage box along with other optional accessories.

Circle (406) on Fast Fact Card

Radiotelephone interconnect supports sampling, repeater use

The PatchMaster 200 radiotelephone interconnect from **Advanced Computer Controls** communicates with users in customized digital voice messages. The phone patch supports sampling, Vox, full-duplex and repeater operation.

Circle (300) on Fast Fact Card



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Circle (72) on Fast Fact Card

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Circle (73) on Fast Fact Card

New products

Fleet management controller allows status reporting, ANI

The TR30-280 fleet management controller fits any mobile radio to provide single-button status reporting, base call, unit and group call, and ANI and emergency functions. The **Transcrypt** unit includes backlit tactile buttons; rugged construction; high-speed digital signaling; universal interface; programmable signaling options; programmable ANI from keypad; audible feedback; and printer and disk log of all radio transactions available to dispatcher. The controller works with trunked or conventional radios.



Circle (422) on Fast Fact Card

14-channel VHF portables meet military specs

Two VHF portable radios from **Bendix/King** may be programmed to operate on any VHF frequency in the 148MHz-to-174MHz range without degradation in specification. Model EPH514 1A has a seven-character, seven-segment numeric display. Model EPH514 2A offers a eight-character, 14-segment alphanumeric display. Both radios can be programmed for either 5kHz or 12.5kHz channel increments. The portables meet military standard 810C and D, as well as meet or exceed



EIA and U.S. Forestry Service specs.
Circle (408) on Fast Fact Card

VHF mobile antenna includes rugged construction

A wide bandwidth of 135MHz-to-185MHz frequency range and rugged construction are features of **Austin Antennas'** VHF mobile antenna. The antenna has an elevated feedpoint and a urethane spring.

Circle (428) on Fast Fact Card

Tower monitoring service protects against FCC fines

The tower monitoring service from **RTI Communications** protects tower owners and licensees from FCC fines for non-compliance of the commission's rules on tower light monitoring, reporting and record-keeping.

Circle (421) on Fast Fact Card

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Circle (74) on Fast Fact Card

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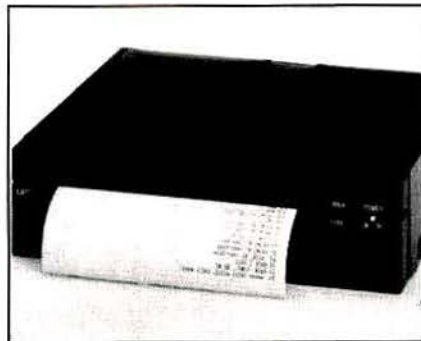
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Circle (75) on Fast Fact Card

Mobile printer operates at 2,400 baud or 9,600 baud



The mobile printer for vehicle applications from Aisin U.S.A. weighs 3.75 pounds and is powered by direct 12V connections. The printer operates at either 2,400 baud or 9,600 baud. The unit withstands -30°C to $+70^{\circ}\text{C}$. The unit's standard RS-232C serial port allows the printer to work with most mobile data terminals, personal computers and data recorders. The printer boasts a 16k buffer for memory.

Circle (500) on Fast Fact Card

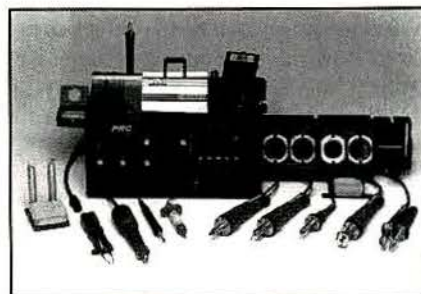
Paging monitoring system works with PC, antenna

The Pagetracker 2000 paging monitoring system works with a PC and antenna. The TSR Technologies system permits continuous monitoring and time-stamped recording of pager IDs and messages of any paging system us-

ing POCSAG 256 baud, 512 baud or 1,200 baud; GSC Golay 300 baud data; and NEC 200 baud data. Traffic activity is displayed on a hard disk for easy retrieval.

Circle (427) on Fast Fact Card

Component repair workstation features 5 handpieces



The PRC 2000 process control system from Pace features five SensaTemp handpieces and a self-contained air supply with timing control for dispensing of solder cream and other materials. The component installation and repair workstation offers variable, controlled and low-voltage ac pulse power to handpieces.

Circle (398) on Fast Fact Card

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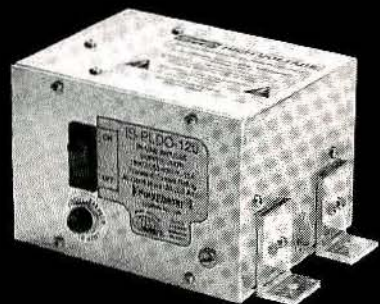
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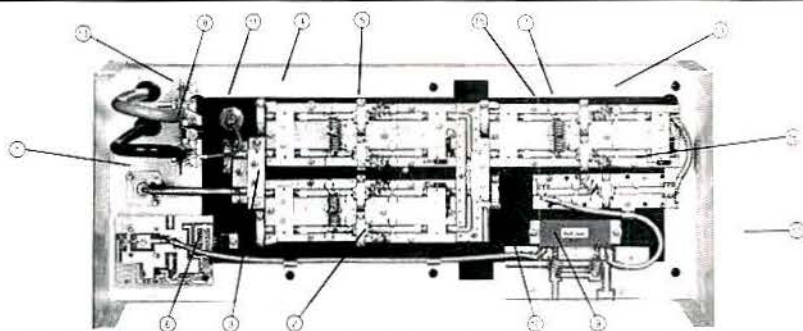
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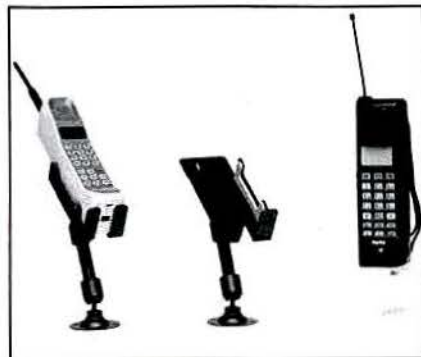
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Circle (78) on Fast Fact Card

New products

Cellular phone cradles sport foam inserts



Models 602 and 607 cellular portable telephone cradles from **SMC Electro-Mount** have Velcro fasteners and foam inserts. The cradles work with the company's mounting hardware.

Circle (331) on Fast Fact Card

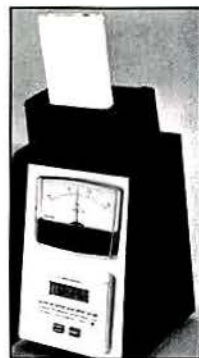
Logic board fits Uniden radios

The Versa logic board from **SMC Wireless** fits Uniden SMS 300 series radios. It features increased channel capability to 99 systems and as many as 1,000 groups; selectable normal or priority scan; out-of-range queuing; PC programmability through the handset cable; and selectable audio companding on dispatch and interconnect.

Circle (415) on Fast Fact Card

Cordless tester calculates mAh rating of batteries

A cordless battery tester is available that calculates the mAh rating of rechargeable batteries. The tester consists of a voltmeter, digital timer and electronics to control the discharge of a fully charged battery. The **Motorola Worldwide System** and **Aftermarket Products Division** unit can be wall-mounted, and it has a full line of adapters and adapter cables to test almost any battery.



Circle (359) on Fast Fact Card



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Circle (79) on Fast Fact Card

Catalog lists battery equipment

NiCd, Lexstar, mercury, alkaline batteries for cellular telephones, pagers and other mobile radio equipment are listed in **Alexander Batteries'** catalog. Descriptions, cross-reference information, specifications and talk-time are featured. Battery testing and maintenance equipment are included.

Circle (283) on Fast Fact Card

Spanish catalog features cellular accessories

Cellular Solutions has a Spanish language version of its cellular accessory catalog. The catalog offers power supplies, transportable kits, interface devices, mobile antennas, mobile mounts and other cellular accessories.

Circle (279) on Fast Fact Card

Book describes, lists radio communications sites

Covering nearly all of California and including major portions of southern Nevada and western Arizona, *Radio Sites of Central and Southern California* provides information on nearly 400 individual radio sites that supply or accommodate two-way radio equipment. The book provides two-color maps; an alphabetical list of the radio sites; coordinates and general site usage; and frequency coordinating committees for commercial, broadcast, industrial, public safety and amateur services. The publication is from **Arroyo Borracho Press**.

Circle (278) on Fast Fact Card

Brochure describes cellular antennas

Cellular 3dB antennas are described in **db Mobile's** brochure. The GlasLink and CelLink lines are featured along

with phone holders, mounts, replacement antennas and leather cases.

Circle (282) on Fast Fact Card

Study predicts SCADA growth in 1990-1995

Three principal SCADA end-user market sectors: oil and gas energy, electric utilities, and water and wastewater utilities are addressed in a four-volume *SCADAVIEWS Market Research Reports Series*. The primary report, "Challenges and Opportunities in the SCADA

Marketplace (1990-1995)," provides information about the three principal end-user market sectors including a thorough analysis of issues, trends and market forecasts through 1995. The market study is available from **Tech-Marc**.

Circle (277) on Fast Fact Card



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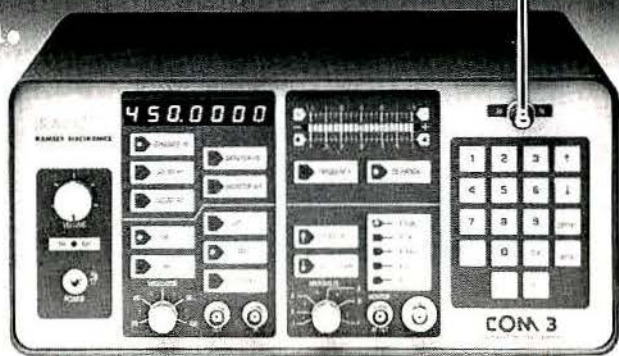
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Circle (83) on Fast Fact Card

Feedback

Land mobile radio continues to grow

Land mobile radio communications continues its upward growth, according to the respondents to the September 1991 "What Do You Think?" questionnaire. The majority of the respondents at 46.9% report a quick growth spurt, with 31.3% indicating a moderate growth.

Only 3.1% of the respondents note "little or no growth" in the land mobile industry, with 18.8% reporting "slow" growth.

Contributions to the growth of mobile radio, according to readers, include:

- "Increased cellular activity and paging."
- "Low-cost programmable radios on the market."
- "Moving from analog to digital."
- "Price of equipment is going down and the size of equipment is getting smaller and the reliability of it is going up."
- "Trunking and mobile data terminals."
- "Programmable radios have helped. Overcrowding of frequencies has hindered growth. The rural economy has hurt."

The development of personal communications networks (PCNs) will affect the mobile radio industry in various ways such as make land mobile more competitive, cause some shakeouts in industry players and expand opportunities for revenue. Readers believe the development of PCNs will have the following effects:

- "We'll be able to load more, i.e. trunking and more."
- "It will cause more attention to user needs and system design for needs, rather than just selling a radio."
- "Add competition for the dollar."
- "More companies, more possibilities, variations, specialized needs being filled."
- "Will open consumer market to two-way radio."
- "Will bring new technologies to the marketplace. This new technology will be 'refarmed' into present systems."
- "There will be old players and new players in a different game."
- "PCNs shouldn't bother traditional two-way accounts and public safety, but it might hurt cellular."

The industry constantly is changing, and readers note some of the recent developments:

- "It is becoming more challenging."
- "Less expertise is required of technicians as circuits become more modularized."
- "More applications are being found for RF applications."
- "The industry is changing fast. Standards are not established before another leap."
- "Cheaper equipment is being introduced, and there are too many mail order houses."
- "Everybody wants 'E' prom and 'non-radios.' Crystals are out, like tubes."
- "End-users are becoming more price- and quality-conscious."

Factors that will cause changes in the near future include:

- "A decline in component level repair."
- "Lower cost systems."
- "Some people who went to cellular are coming back to standard two-way because of costs."
- "PCs will take over."
- "More computerized, no component level repair."
- "Smaller programmable units with more channels and better batteries."
- "Digital modulation techniques will be used in all market applications."

Be sure to fill out this month's "What Do You Think?" questionnaire on page 97 so your responses can be included in a future "Feedback" column.

What do you think?

How do you view the PCP market?

NOTE: Please indicate your response to each question by marking the appropriate box. If you are unsure, please mark "N/A".

1. What is your TITLE?	2. What is your COMPANY?	3. How do you view the PCP market?	4. How do you view the PCP market?
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NAME _____ PHONE () _____

Mary Beth Richards advances from Common Carrier Bureau Enforcement Division chief to Enforcement Division chief of the FCC Field Operations Bureau, Washington, DC.

Duane L. Huff leaves AT&T Bell Laboratories, Cellular Systems Test, as department manager to join Comcast Cellular Communications, Philadelphia, as director of new technologies.

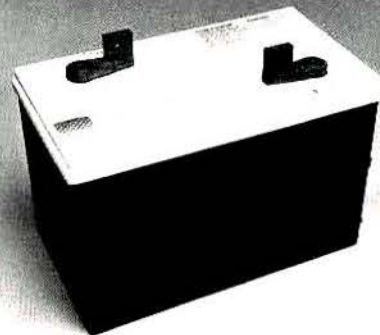
Charles Mason, director of Cellular Data, Mountain View, CA, adds to his responsibilities the volunteer position as head of the Mobile Data Working Group, a membership section of Telocator's Personal Communications Service.

Brian Stern leaves Electronic Data Systems, Lakewood, CO, as consultative sales manager to join Cellular Solutions, Boulder, CO, as eastern region division sales manager.

Janice Obuchowski resigns as the U.S. Commerce Department assistant secretary in charge of the National Telecommunications and Information Administration to establish a research and consulting firm specializing in telecommunications.



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Calendar

March

29-April 1—Energy Telecommunications and Electrical Association '92, Dallas Convention Center, Dallas. Contact: 214-235-0655.

April

12-15—North Central Regional Conference Associated Public-Safety Communications Officers Meeting, Pheasant Run Resort and Convention Center, St. Charles, IL. Contact: T.G. Miere, 708-244-8640.

May

7-9—1992 Annual Mobile Communications Conference, Westin ANA Hotel and Resort, Washington, DC. Contact: National Association of Business and Educational Radio, 800-759-0300.

11-13—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Hyatt Regency, Denver. Contact: John Tary, 303-452-6111, ext. 443.

13-15—RadioComm Annual Convention, Montreal. Contact: Lisa La Prairie, 613-233-4888.

17-20—East Coast Regional Conference Associated Public-Safety Communications Officers Meeting, Lancaster Host Resort, Lancaster, PA. Contact: James Giannini, 215-631-6500.

June

17-19—Virginia Tech Symposium on Wireless Personal Communications, Virginia Tech, Blacksburg, VA. Contact: Jack Lilly, 703-231-4849.

21-25—Utilities Telecommunications Council 44th Annual Meeting, Hyatt Civic Plaza, Phoenix. Contact: Rita Clark, 301-621-7802.

July

19-23—Forestry-Conservation Communications Association, Toledo, OH. Contact: Don Pfohl, 602-644-3166.

August

9-14—Associated Public-Safety Communications Officers 58th National Conference, Washington State Convention Center, Seattle. Contact: 800-824-1850.

September

1-3—International Mobile Communications Expo/Fall, Georgia World Congress Center, Atlanta. Contact: 303-220-0600.

22-25—Mobile Communications Marketplace, Moscone Center, San Francisco. Contact: Telocator, 800-326-8638.

October

8-10—Special Industrial Radio Service Association Annual Meeting, Grove Park Inn, Asheville, NC. Contact: Barbara J. Levermann, 703-528-5115.

24-29—International Association of Chiefs of Police 98th Annual Conference, Detroit and Windsor, Ontario. Contact: 703-243-6500.

November

12-15—Communications Marketing Conference, John Ascauga's Nugget Hotel, Reno, NV. Contact: Gene Johnson, Vega Signaling, 818-442-0782.

20—Radio Club of America Annual Meeting and Awards Banquet, New York Athletic Club, New York. Contact: 201-246-7271.



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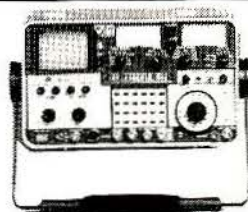
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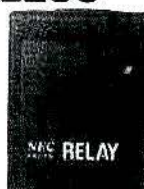
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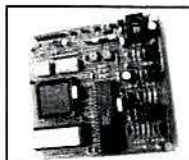
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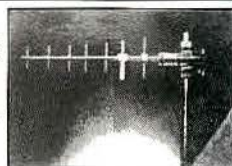
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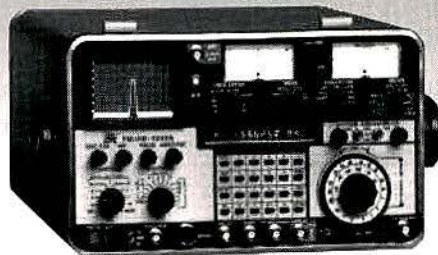
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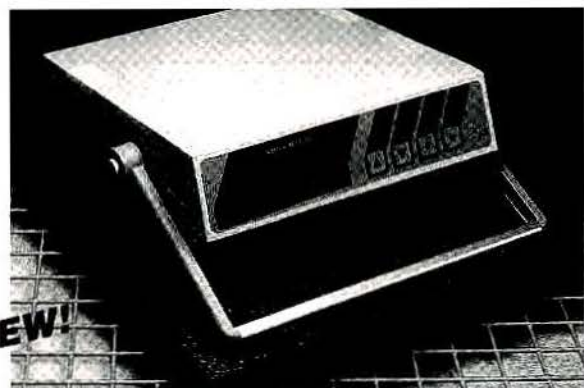
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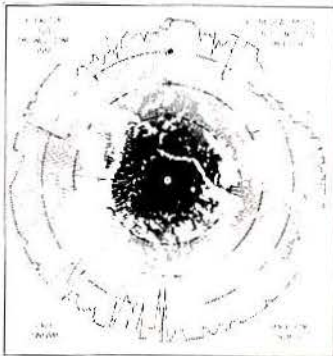
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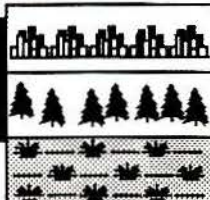
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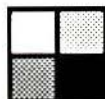
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The Antenna Specialists Co.	24	22	216-349-8400	Motorola Government	27	25	800-235-9590
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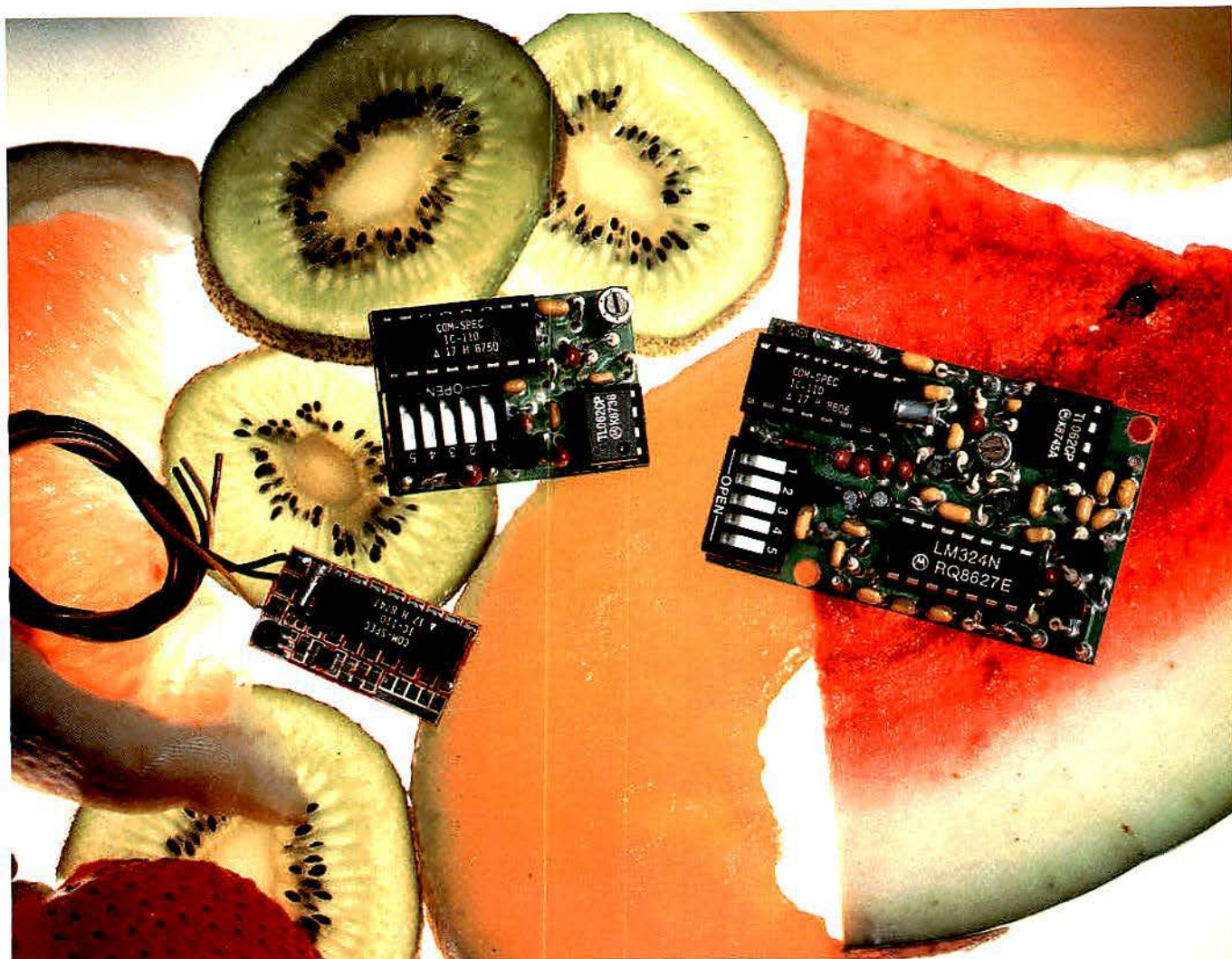
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